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REPORT

ON THE

DANISH OCEANOGRAPHICAL EXPEDITIONS 1908-1910

TO THE

MEDITERRANEAN AND ADJACENT SEAS

PUBLISHED AT THE COST OF THE CARLSBERG FUND

UNDER THE SUPERINTENDENCE OF

JOHS. SCHMIDT, PH. D.

DIRECTOR OF THE CARLSBERG PHYSIOLOGICAL LABORATORY, COPENHAGEN,
MEMBER OF THE DANISH COMMITTEE FOR THE STUDY OF THE SEA,

LEADER OF THE EXPEDITIONS

N° 7

VOL. II (Biology), A. 10: Lophius by Å. V. TÅNING.
— - — D. 3: Decapoda-Macrura (excl. Sergestidæ) by K. STEPHENSEN.
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— - — — 5: Experiments with drift-bottles (2nd Report) by GIOVANNI PLATANIA.

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List of Papers resulting in whole or in part from the Cruises of the Danish Research-Steamer "Thor" in the Atlantic and Mediterranean.

1. Hydrography.

J. P. JACOBSEN, in Schmidt, Nielsen og Jacobsen: Fra den danske oceanografiske Expedition til Middelhavet i Vinteren 1908—1909. (Geografisk Tidsskrift, 20. H. VI, København 1910).

MARTIN KNUDSEN: Danish Hydrographical Investigations at the Faroe Islands in the Spring of 1910. (Meddelelser fra Kommissionen for Havundersøgelser, Serie: Hydrografi, II, No. 1, København 1911.

J. N. NIELSEN: Hydrography of the Waters by the Faroe Islands and Iceland during the cruises of the Danish research-steamer "Thor" in the summer 1903 (ibid. I, No. 4, 1904).

— Contributions to the Hydrography of the Waters north of Iceland (ibid. I, No. 7, 1905).

— Contribution to the Hydrography of the north-eastern part of the Atlantic Ocean (ibid. I, No. 9, 1907).

— Contribution to the understanding of the currents in the northern part of the Atlantic Ocean (ibid. I, No. 11, 1908).

— in Schmidt, Nielsen og Jacobsen: Fra den danske oceanografiske Expedition til Middelhavet i Vinteren 1908—1909 (Geografisk Tidsskrift, 20, H. VI, København 1910).

— Sur les températures des grandes profondeurs particulièrement dans la Méditerranée, Note préliminaire, (Bulletin de l'Institut Océanographique, No. 209, Monaco 1911).

— Hydrografiske Undersøgelser i Middelhavet; De danske oceanografiske Expeditioner i 1908—1910, København 1913.

Numerous observations, sections, etc. from the "Thor" Expeditions in the Atlantic have been published in: Bulletin Hydrographique du Conseil Permanent International pour l'Exploration de la Mer, København 1902 and following years.

2. Biology.

VILH. EGE On the postlarval stages of the species of *Paralepis* inhabiting the North Eastern part of the Atlantic incl. the Mediterranean (Videnskabelige Meddelelser fra Dansk naturhistorisk Forening, Vol. 69, København 1918).

P. JESPERSEN: Contributions to the Life-History of the North Atlantic Halibut (*Hippoglossus vulgaris* Flem.) (Meddelelser fra Kommissionen for Havundersøgelser, Serie: Fiskeri, Bind V, No. 5, København 1917).

— On the Occurrence of the Postlarval Stages of the Herring and the "Lodde" (*Clupea harengus* L., and *Mallotus villosus* O. F. M.) at Iceland and the Færoes, (ibid. Bind VI, No. 1, 1920)

P. JESPERSEN and A. VEDEL TANING: Some Mediterranean and Atlantic Sternoptychidae. (Videnskabelige Meddelelser fra Dansk naturhistorisk Forening, Vol. 70, København 1919).

C. H. OSTENFELD: *Thorosphaera*, eine neue Gattung der Coccolithophoriden (Berichte der deutschen Botanischen Gesellschaft, Bd. 28, Berlin 1910).

OVE PAULSEN: Plankton-Investigations in the Waters round Iceland in 1903 (Meddelelser fra Kommissionen for Havundersøgelser, Serie: Plankton, I, No. 1, København 1904).

— On some Peridineae and Planktons Diatoms (ibid. I, No. 3, 1905).

— Studies on the biology of *Calanus finmarchicus* in the waters round Iceland (ibid. I, No. 4, 1906).

— Plankton Investigations in the Waters round Iceland and in the North Atlantic in 1904 (ibid. I, No. 8, 1909).

— The plankton on a submarine bank (in Biologiske Arbejder tilegnede Eug. Warming d. 3. Nov. 1911, København 1911).

C. G. JOH. PETERSEN: On the Larval and Postlarval Stages of the Long Rough Dab and the Genus *Pleuronectes* (Meddelelser fra Kommissionen for Havundersøgelser, Serie: Fiskeri, I, No. 1, København 1904).

C. G. JOH. PETERSEN: Larval Eels *(Leptocephalus brevirostris)* of the Atlantic Coasts of Europe (ibid. I, No. 5, 1905).

— On the young stages of the Genus *Zeugopterus* (Report of the Danish Biological Station, XII, København 1905).

— On the Larval and Post-Larval Stages of some *Pleuronectidae (Pleuronectes, Zeugopterus)* (Meddelelser fra Kommissionen for Havundersøgelser, Serie: Fiskeri, II, No. 1, København 1906).

— On the Larval and Postlarval Stages of some *Pleuronectidae (Zeugopterus, Arnoglossus, Solea)* (ibid. III. No. 1, 1909).

LOUIS ROULE: Étude sur les formes larvaires Tiluriennes de Poissons Apodes recueillies par le "Thor" (Annales de l'Institut Océanographique, T. VI, Fasc. 2, Monaco 1913).

JOHS. SCHMIDT: Fiskeriundersøgelser ved Island og Færøerne i Sommeren 1903 (Skrifter udgivne af Kommissionen for Havundersøgelser, No. 1. København 1904).

— On Pelagic Post-Larval Halibut *(Hippoglossus vulgaris* Flem. and *H. hippoglossoïdes* [Walb.]) (Meddelelser fra Kommissionen for Havundersøgelser, Serie: Fiskeri, I, No. 3, København 1904).

— The Pelagic Post-Larval Stages of the Atlantic Species of *Gadus*, Part I (ibid. I, No. 4, 1905).

— On the Larval and Post-Larval Stages of the Torsk (*Brosmius brosme* [Ascan.]) (ibid. I, No. 8. 1905).

— The Pelagic Post-Larval Stages of the Atlantic Species of *Gadus*, Part II, (ibid. II, No. 2, 1906).

— On the Pelagic Post-Larval Stages of the Lings (*Molva molva* [Linné] and *Molva byrkelange* [Walb.]) (ibid. II, No. 3, 1906).

— On the Larval and Post-Larval Development of the Argentines (*Argentina silus* [Ascan.] and *Argentina sphyræna* Linné with notes on *Mallotus villosus* [O. F. Müll.]) (ibid. II, No. 4, 1906).

— Contribution to the Life-History of the Eel (*Anguilla vulgaris* Turt.) (Rapports et Procès-Verbaux du Conseil International pour l'Exploration de la Mer, Vol. V, No. 4, København 1906).

— Marking Experiments on Plaice and Cod in Icelandic Waters (Meddelelser fra Kommissionen for Havundersøgelser, Serie: Fiskeri, II, No. 6, København 1907).

— On the Post-Larval Development of the Hake (*Merluccius vulgaris* Flem.) (ibid. II, No. 7, 1907).

— On the Post-Larval Development of some North Atlantic Gadoids (*Raniceps raninus* [Linné] and *Molva elongata* [Risso]) (ibid. II, No. 8, 1907).

— On the Post-Larval Stages of the John Dory (*Zeus faber* L.) and some other Acanthopterygian Fishes (ibid. II, No. 9. 1908).

— Remarks on the Metamorphosis and Distribution of the Larvae of the Eel (*Anguilla vulgaris* Turt.) (ibid. III, No. 3, 1909).

— On the Occurrence of Leptocephali (Larval Muraenoids) in the Atlantic W. of Europe (ibid. III, No. 6, 1909.

— On the Distribution of the Fresh-Water Eels (*Anguilla*) throughout the World, I. Atlantic Ocean and Adjacent Regions (ibid. III, No. 7, 1909).

— The Distribution of the Pelagic Fry and the Spawning Regions of the Gadoids in the North Atlantic from Iceland to Spain (Rapports et Procès-Verbaux du Conseil International pour l'Exploration de la Mer, Vol. X, No. 4, København 1909).

— Exposé sommaire des travaux de l'expédition océanographique danoise dans la Méditerranée (1908—1909) (La Géographie, XXI, 2, Paris 1910).

— Leptocephalus hyoproroïdes and Lept. thorianus (Zoologischer Anzeiger, XXXVI, No. 2—3, Leipzig 1910).

— Résultats préliminaires de l'expédition océanographique danoise dans l'Atlantique et la Méditerranée pendant l'été 1910 (La Géographie, Paris 1911).

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VOL. II: BIOLOGY

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REPORT ON THE DANISH OCEANOGRAPHICAL EXPEDITIONS 1908—10
TO THE MEDITERRANEAN AND ADJACENT SEAS
Vol. II. Biology.

A. 10.

Lophius

By

Å. Vedel Tåning.

With 22 figures in the text.

Published November 30, 1923.

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INTRODUCTION.

During the past 25 years, the operations of the International Investigation of the Sea have been extended to embrace also the free water masses of the open Atlantic, whereby the breeding grounds and early development of several of the catadromous fishes have been brought to our knowledge. Among the species thus included is our sole representative of the *Pediculati: Lophius piscatorius* L., the Angler, which moves during the breeding season out towards the depths which form the haunts of a great number of its relatives: the *Ceratiidæ* etc.

The material on which the present little work is based was taken by the "Thor" in 1903—1908 under the direction of Dr. Johs. Schmidt. Dr. Schmidt has previously (1906 p. 177 and 1909 p. 92) pointed out that the breeding grounds of *Lophius piscatorius* were to be found in deep water west of the British Isles; it is only now, however, that we are able to furnish the details as to the spawning area of the species in question.

The visits of the "Thor" to the area where the *Lophius* spawns in the Atlantic were confined to the months of May to September (see lists p. 27). Abt. 225 postlarval stages were taken, the majority in May/June, only very few in the following months. The sizes vary from abt. 7 to 60 mm (under 20 mm: 142 spec.; 20—30 mm: 23 spec.; 30—40 mm: 19 spec.; over 40 mm: 5 spec.); moreover, a part of the material was only entered in the fishing journals, and subsequently lost. The material is preserved in formalin (4 %), and in the course of years, the pigmentation in particular has suffered a good deal.

One or two unfortunate circumstances in connection with the material must be noted, viz: that it is pieced together from the cruises of several years, and that investigations are lacking for October/April in the northern spawning grounds of the species. The "Thor" cruised the Bay of Biscay in March, June, September and about the 1st December (1908, 09 and 10) without finding postlarval stages at the comparatively few stations there. The "Dana", working in September 1921 and Juni 1922, had not better fortune here.

Out in the open Atlantic west of the British Isles and farther south, beyond the limits fished by the "Thor", (at abt. 16° W.) neither the "Margrethe" (1913) nor the various vessels fishing in our service (1911—15) nor the "Dana"-cruises (1920—22) yielded young of the *Lophius*, so we may doubtless be justified in concluding that the tiny stages are not found very far out beyond the continental slope.

Without going further into the historical side of the question as to our knowledge of the earliest developmental stages of the species, we may mention that A. Günther seems to be the first author to show a postlarval stage (1861, after Dr. Rüppel's sketch of a specimen from the Mediterranean). The development of the American form, however, was very thoroughly known before that of the North-European form, as owing to the natural conditions of the east coast of America; the development of the species from its earliest stages here takes place close in to land, and material was thus early obtained by the marine biologist A. Agassiz (1878, 1882, 1885). M'Intosh and E. Prince have described quite young stages of the European form (1890—92) and among later works those of G. Stiasny, on the Adriatic form (1911 and 1913)

should be particularly noted, as also ALEX. BOWMAN'S valuable work (1920) on stages from the Scottish waters. While referring the reader especially to these last two writers, I would point out that the present work is the first which extends our knowledge to the pelagic stages of the North-European form over 17 mm.

GEOGRAPHICAL DISTRIBUTION OF THE GENUS IN THE ATLANTIC AND ADJACENT SEAS.

As regards the northern waters, at any rate, the distribution of *Lophius piscatorius* in the shallower parts is fairly well known; we find it in Danish waters, for instance, in the northern part of the Sound and up in the Western Baltic. On moving out to the periphery of its area of distribution, however, the main centre of which in Northern Europe seems to lie about the British Isles, more precise knowledge is lacking. Not so much to the north, for here, the species is found on important fishing grounds; it has been taken as far as the northernmost parts of Norway, and in the White Sea, as also off the coasts of Iceland, where, however, according to B. SÆMUNDSSON, the N. and E. coasts show only an isolated find in the trawl in alternate years, whereas on the S. and W. coasts, it is more numerous. In the North Sea especially, along the western and southern shores of the British Isles and in the Bay of Biscay, it is of frequent occurrence. Along the coast of Portugal, its distribution has been but little investigated, as far as we know, but it is found here, and since it is used as food by the inhabitants, it cannot be altogether rare.

The Fishery Statistics (here quoted from: Bulletin Statistique des Pêches Maritimes, Vol. III—X. Cons. Perm. Intern. pour l'Expl. de la Mer) gives a very good survey of the distribution in the western and north-western waters of Europe. The mean quantity for *Lophius* landed in the years 1906—14, all areas, is abt. 3187 tons per annum (post-war statistics are only applicable from 1920, so we have here only included the 9 years above noted). The mean quantities for separate areas 1906—14 are as follows:

Iceland	47.7	West coast of Ireland	19.6
Færoes	49.7	South — - —	368.6
North Sea	1.873.8	South coast of England	253.2
Skagerrack	105.8	West — - —	119.4
Kattegat	2.9	Bay of Biscay	26.7
Rockall and West coast of Scotland and North coast of Ireland	301.3	Southern waters (Portugal & Morocco)	17.9

Compared with the quantities of other fish, these figures of course are low; the percentage for the North Sea, for instance only abt. 0.2% of all fish landed in the year, and somewhat more in the area about the Bay of Biscay. From the Norwegian Sea no information is available, but in 1912 we have abt. 0.2 tons from the White Sea and in 1913 abt. 0.6 tons from the Barents Sea. The Rockall Bank itself shows abt. 1—9 tons per annum. A few tons yearly (1—63) cannot, according to the statistics, be referred to any particular area among those noted.

An investigation of the distribution of *Lophius* at the small islands of the Eastern Atlantic gives the following result:

Azores. Col. F. A. CHAVES, the well-known authority on the natural history of the Azores, informs us in a letter that the species is not common there; all the fishermen, however, are acquainted

with it. The average size is as a rule 80 cm, but the museum at Ponta Delgada has a specimen 148 cm. long (52 cm. across). VAILLANT (1888) mentions the species (expressly noted as *L. piscatorius*) both from the Azores (1 spec.) and from Cape Verde Islands. The "Talisman" took 5 specimens in all, ranging from 8—9 to 25—27 cm; the size of the specimen from the Azores is not stated. An investigation of specimens here and from America may possibly show that the specimens from the Azores are of American, and not of European origin.

Madeira. LOWE (1841) expressly states that no Lophiids are found at Madeira. A letter from Mr. A. C. DE NORONHA, who is particularly well acquainted with the fish-fauna of Madeira, confirms this; and the writer adds, that the fishermen there do not know the fish.

Canaries. *Lophius* is not mentioned from here in the ichthyological literature (nor in BARKER-WEBB et SABIN BERTHELOT: Hist. Naturelle des Isles Canaries, Paris 1836—44); from the fact that it is found on the coast of Morocco, however, it must be presumed that it might also be found at the Canaries.

Cape Verde Islands. VAILLANT (1888) records 4 specimens from here (see supra). It should here be added that J. METZELAAR (1919) notes *Lophius budegassa*, Spinola, from the west coast of Africa, abt. 24° N. (Rio d'Ouro).

From the Bay of Cadiz, HOLT & BYRNE (1909) note *Lophius budegassa*.

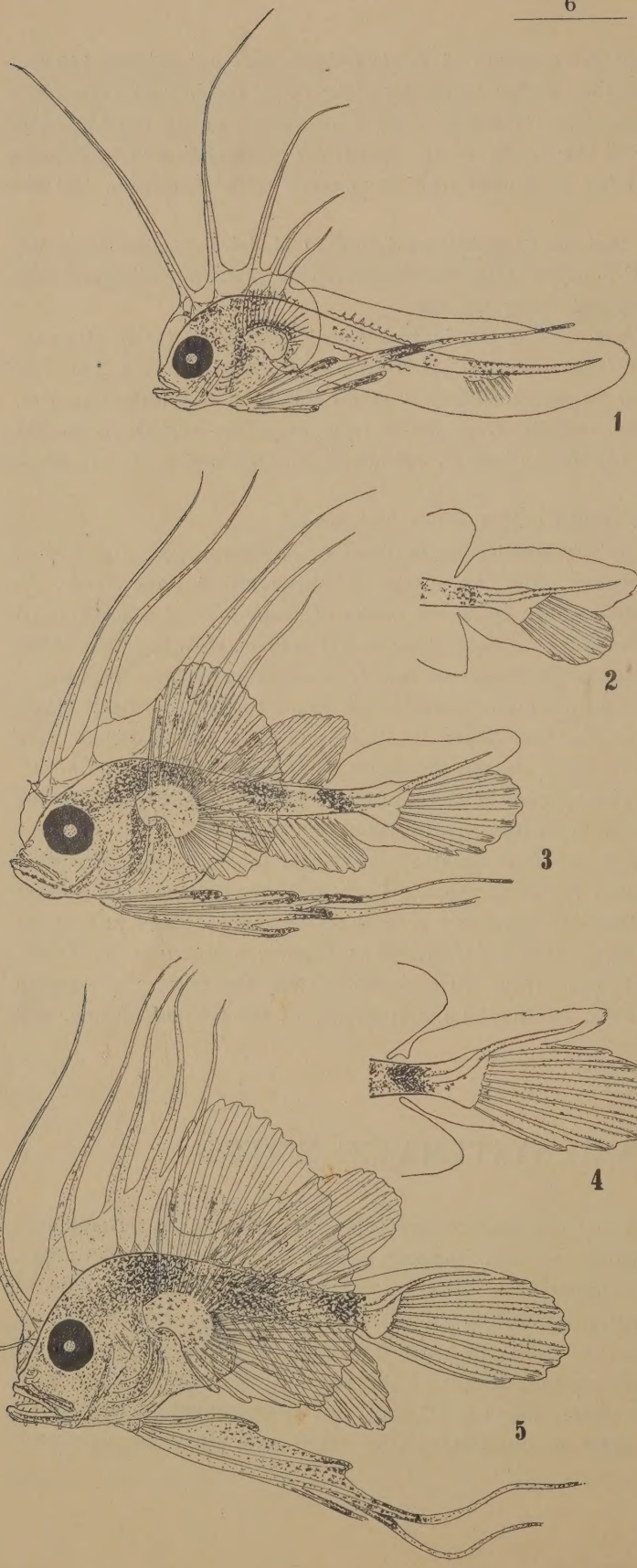
These last mentioned writers thus record the Mediterranean form *L. budegassa* from the Bay of Cadiz and southward from there, whereas VAILLANT calls the species *L. piscatorius* at Cape Verde. As mentioned below, the rigth to maintain two Mediterranean forms of *Lophius* (*piscatorius & budegassa*) must be subjected to closer examination. It will suffice here to note that several writers maintain two Mediterranean species, the distribution, spawning grounds, development etc. of these being partly unknown.

South of Cape Verde, the species *Lophius piscatorius* is recorded as far as the Cape of Good Hope, especially by older writers. GILCHRIST (1922) records both from the Cape and Natal seas, though very few in the latter, *Lophius upsicephalus*, Smith. In these waters, the genus *Lophius* meets that of *Chirolophius* from the Indian Ocean and the Pacific. The species in the southern Atlantic should, as with the possible two from the Mediterranean, be subjected to further investigation.

On the eastern side of the Atlantic then, we find, as it appears from the foregoing, according to some writers, one species, while others maintain three; on the western side, we find a single species generally noted (the same as in the eastern Atlantic) and this is said to be found at any rate as far south as abt. 23° S. (REGAN, 1914). The American *Lophius* (described as *Lophius americanus* by Valenciennes 1837) is stated to be found in the adult stages from Nova Scotia to Cape Hatteras as a common form, not frequent up on the Newfoundland Banks, south of Cape Hatteras, in the Gulf of Mexico, and at Barbados. It is not found at Bermuda.

ONTOGENETICAL AND SYSTEMATIC NOTES.

In the following pages, we shall give, in the first place, some brief information as to development of the postlarval stages up to the length at which we may suppose pelagic life to cease; and further, mention various characters and make certain comparisons, such as our material permits, by way of contribution to the question as to degree of relationship between the American form, the North-European form and that — or those — of the Mediterranean. ALEX. BOWMAN has given a detailed description of the postlarval stages of the North-European form up to a length of 16 mm, and as STIASNY has given a fine series of postlarvæ and quite small bottom stages, showing generally the development of older postlarvæ of the genus *Lophius*, it will suffice to refer to our figures (figs. 1—8) and otherwise give some brief observations on the development.



Figs. 1—5. Postlarval stages of *Lophius piscatorius*, L. Fig. 1. Ca. 11.5 mm (St. 52—1906). Fig. 3. Ca. 16.5 mm (St. 52—1906). Fig. 5. Ca. 26 mm (St. 165—1905). Fig. 2 and 4, the caudal part of the notochord in specimens ca. 14 and ca. 21 mm's.

Careful measurement (which, by the way, with these young forms is rendered difficult by their lack of firmness) made with about a score of different dimensions for postlarvæ ranging from abt. 10—60 mm, and the calculation of these dimensions in proportion to total length ex. caudal fin[1] gives us material for the following observations as to change of proportion during process of growth.

Generally speaking, we may say that the alteration of the various parts in the postlarva takes place more especially up to a length of abt. 25—30 mm; thereafter follows a period of evidently more uniform growth, succeeded again, when the postlarva has reached abt. 40 mm, by those changes which doubtless in the case of most characters lead gradually over to the small bottom stage which, according to BOWMAN at a total length of abt. 185 mm, "has completed its metamorphosis, and acquired its true bottom form", whereafter "the growth of the different parts is uniform".

On observing a series of characters showing how the increase in length of the different parts of the postlarvæ takes place, it will be seen that no great alteration is made after reaching abt. 25 mm. The preanal length, for instance, begins at about 40 % of total length ex. C. in the postlarva of abt. 10 mm; at a total length of 25—30 mm, the proportion is abt. 60 %; after this, there is hardly any change observable until metamorphosis sets in, when a slight decrease perhaps takes place; in the small bottom stages again, there is a slight increase (BOWMAN). The distance from point of lower jaw to ventral fin gives much the same result; this character, however, alters far less during

[1] This enables us to compare with BOWMAN's similar investigations of small bottom stages p. 15—18 (1920).

the postlarval growth than the pre-anal length. The distances from point of upper jaw to pectoral fin and to anterior margin of eye are as those just mentioned; but the increase is more gradual through most part of the postlarval existence, until the signs of metamorphosis set in at abt. 40 mm length. Dimensions such as the distance from point of upper jaw to base of anterior margin of posterior dorsal fin, or from the point of the lower jaw to the base of anterior margin in the anal fin seem only to increase very slightly in the course of postlarval life; so also with the distance in front of the third ray in the anterior dorsal fin; the two foremost rays, on the other hand, shift forward on to the point of the snout; or more correctly, the growth of the part in front of them stops at a very juvenile postlarval stage (the eye, etc. shifting back); we find, for instance, the distance from point of snout to the first ray gradually decreasing from abt. 20 % to abt. 5 % of the total length ex. C., while the postlarva is growing from abt. 12 mm to 60 mm.

6

7

Figs. 6—7. Postlarval stages of *Lophius piscatorius* L. Fig. 6. 32 mm (St. 74—1905) — (P removed). Fig. 7. 46 mm (St. 72—1905) — (short form, owing to preservation?).

The increase in breadth is of particular interest as regards the head; maximal breadth of head in postlarvæ of abt. 10 mm length is only abt. 15—20 % of total length ex. C.; but on reaching a total length of abt. 40 mm this dimension has, by fairly gradual changes, attained the proportion of abt. 50 % of the total length ex. C. In the small bottom forms, it again decreases slightly. The increase in breadth of the head is expressed in very nearly the same way in the increasing of the length of the upper jaw; the interorbital space, on the other hand, does not appear to expand until a postlarval stage of abt. 25 mm.

The alteration of the height (depth) of the head does not proceed equally with the growth in breadth of the head; the height of the head in small postlarvæ increases slightly until a length of abt. 30 mm is reached, remaining then more or less constant until lateral expansion sets in with the approach of metamorphosis; measurements of height of head, both including and excluding the sub-epidermal space, have been made, and give much the same result. On transition from the postlarval stage to the youngest bottom stage, this sub-epidermal space[1] appears to diminish somewhat abruptly, which was to be expected, as its volume in the postlarva is doubtless connected with the pelagic life of the organism. The position of the eyes is only a little different in postlarval stages near metamorphosis and in small bottom-stages[2].

[1] The large sub-epidermal space is a very peculiar characteristic in the *Lophius* postlarva, and we find it in all the *Pediculati*, whose postlarvæ we have been able to observe (*Lophiidæ, Antennariidæ, Onchocephalidæ, Ceratiidæ, Aceratiidæ*); these are all pelagic.

[2] The diameter of the eye is perhaps somewhat greater in postlarvæ of 10—20 mm, than in subsequent stages; there is, however, only a little alteration in the relative size of the eye.

Increase in length of the fins proceeds more or less according to the foregoing: an increase in relative length until the postlarva is abt. 25 mm; thereafter only growth, and finally, the incipient reduction in length. The earliest indication of the second dorsal, the anal and the caudal fins appears when three rays are visible in the anterior dorsal, three rays formed in the ventral, and faint indications of rays are seen in the pectoral fin at its upper part (9.5—10 mm). Correspondingly, the former never attain to the size of the latter in the postlarva. The development is mentioned in the literature, and it will therefore suffice here to refer to this and to our figures. A comparison of the figures on p. 6 and p. 15 shows that the development of the American form is far more advanced than that of the European at the same length.

O. Winge phot.
Fig. 8. Postlarval stage of *Lophius piscatorius*, L. 60 mm (St. 165—1903).

The caudal part of the notochord, which, on the first indications of caudal fin formation, commences to decrease in length, should, however, be briefly glanced at here. In specimens of abt. 10—12 mm, this part of the chorda amounts to abt. 27—28 % of the total length ex. C. (reckoned to middle of indication of caudal fin); in specimens of abt. 15 mm, it is abt. 25 %, or equal to the length of the caudal fin; in specimens of 20 mm or a little over, it has dwindled to 22 %, and on reaching a total length of 25 mm, it has evidently ceased growing altogether, its proportion to total length of the fish ex. C. thus rapidly declining (only abt. 9 % in the specimen of 60 mm). In making comparison of the age of the various stages, and comparing various forms of the genus *Lophius*, the stage of development of the notochord is of some importance (cf. figs. 1—5 and 19—21). Taking, for instance, small postlarvæ (abt. 10—15 mm) of the Adriatic and American forms together with North-European specimens of the same length, the retrograde development of the point of the notochord is seen to be far more pronounced in the former than in the latter. The progressive development of the paired and unpaired fins likewise points, as mentioned, in the same direction.

An interesting feature is the growth of the first ray in the anterior dorsal fin, and of the filaments in the ventral fin. The development of the former is subjected to detailed consideration in the following, and its growth differs from that of all other characters investigated in the fact that it evidently, from its first formation to far on in the adult stages gradually increases in relative length. The growth of the remaining rays in D_1 on the other hand, is reduced as the postlarva approaches metamorphosis. The long filaments at the point of 4. and 5. (and 6.) rays in the ventral fin provide a very peculiar character in the *Lophius*-postlarva; these filaments, which exhibit an extremely rapid growth, from the first hatching out of the larva until a length of abt. 25—35 mm is reached, seem, however, in the North-European form, hardly to attain the length found in the Adriatic and American forms; unfortunately, the filaments are in most cases badly damaged, but they seem only to attain about one time the length of body. How their reduction takes place, or whether they simply fall of, we cannot determine.

Measurement from a series of selected specimens.

(For each specimen the length without caudal fin has been used as standard, and we give in brackets the measurements calculated as percentages of this standard length).

Total Length in mm	Length without Caudal Fin	Length of Pectoral Fin	Distance from Upper Jaw to third ray in first Dorsal Fin	Distance from Upper Jaw to Pectoral Fin	Distance from Upper Jaw to Eye	Distance from Lower Jaw to Ventral Fin	Distance from Lower Jaw to Anus	Greatest Breadth of Head	Depth of Head inclusive sub-epidermal space [1]	Depth of Head exclusive sub-epidermal space
9.8	**7.2**	1.6	2.3	1.7	0.4	1.5	3.0	1.2	2.4	2.1
		(22.2)	(31.9)	(23.6)	(5.5)	(20.8)	(41.7)	(16.6)	(33.3)	(29.2)
11.3	**8.2**	2.0	2.8	2.3	0.4	2.0	3.5	1.9	3.2	2.6
		(24.4)	(34.1)	(28.6)	(4.9)	(24.4)	(42.7)	(23.2)	(38.0)	(31.7)
13.3	**9.7**	2.6	3.3	3.0	0.6	2.5	4.3	2.6	3.8	2.9
		(26.9)	(34.0)	(30.9)	(6.2)	(25.8)	(44.5)	(26.8)	(39.2)	(29.9)
16.7	**12.5**	5.4	4.5	4.1	0.8	3.1	7.0	3.5	5.5	4.5
		(43.2)	(36.0)	(32.8)	(6.4)	(24.8)	(56.0)	(28.0)	(44.0)	(36.0)
21.5	**15.5**	6.2	5.4	4.8	1.5	4.5	9.5	5.1	6.5	5.3
		(40.0)	(34.8)	(30.9)	(9.7)	(29.0)	(61.3)	(32.9)	(41.9)	(34.2)
27.0	**18.9**	10.0	7.0	8.1	2.2	5.5	11.2	7.8	8.5	7.2
		(52.9)	(37.0)	(42.9)	(11.6)	(29.1)	(59.3)	(41.3)	(44.9)	(38.1)
32.1	**23.0**	11.2	7.8	9.3	2.6	7.0	15.5	8.9	10.6	9.1
		(48.7)	(33.0)	(40.4)	(11.3)	(30.4)	(66.5)	(38.8)	(46.9)	(39.6)
39.5	**27.3**	13.0	10.0	12.0	3.8	8.2	15.8	13.0	13.0	10.2
		(47.6)	(36.9)	(43.9)	(13.9)	(30.0)	(57.9)	(47.6)	(47.4)	(37.4)
44.8	**32.1**	17.0	12.5	15.5	5.0	9.0	21.5	17.0	16.0	13.2
		(52.9)	(38.9)	(48.3)	(15.6)	(28.0)	(66.6)	(52.9)	(49.8)	(41.1)
60.0	**44.0**	21.0	15.0	20.5	7.0	12.6	27.5	22.0	18.0	15.5
		(47.7)	(34.1)	(46.6)	(15.2)	(28.6)	(61.4)	(50.0)	(40.9)	(35.2)

[1] Distance from Ventral Fin to third ray in first Dorsal Fin.

The fin itself, apart from the filaments, is normal in growth, and evidently follows the pectoral fin both in growth and reduction.

With regard to proportions, no particular difference has been noted between the American and the North-European form; the distance from the eye to tip of upper jaw, however, does seem greater in the American form (see also remarks as to tip of notochord and D_1 I).

Development of the first ray in the anterior dorsal fin (D_1 I) proceeds in detail as follows:

In North-European specimens of **10** mm, there is still very little to be seen of D_1 I; spec. of **11** mm show it as a thickening at the base of D_1 II; at **13** mm, D_1 I, now plainly visible in the sub-epidermal space, lifts up its tip in a small depression in front of D_1 II; and in specimens of **15** mm, it extends abt. 0.5 mm beyond the outline; the median point is set off behind the distal point of the ray itself, but is only abt. $^1/_5$ of this. The distal point of the ray (terminal process) is visible in all subsequent stages on the foreside of the ray.

At a length of abt. **21** mm, D_1 I is a good 1 mm beyond the outline; it is distinctly thickened in its distal part, which makes up over $^2/_3$ total length; the median point is already curved forward, thus forming a slight hollow over the terminal process. At **28** mm length, D_1 I is abt. 1.7 mm, and the distal thickening amounts to barely half its length. The median point (see fig. 9), which must be regarded as a continuation of the carinately elevated posterior side of the ray, is now very distinctly set off, and the

Fig. 9. 11. Tentacles of *L. boreale* (Sars). Fig. 9, specimen ca. 28 mm. Fig. 10, specimen ca. 32 mm. Fig. 11, specimen ca. 38 mm. (The marks in figs. 9 and 10 indicate 1 mm from the tip of the ray; in fig. 11 the mark indicates 1.5 mm. Figs. 10 and 11 in anterior and posterior view.)

the largest postlarva (60 mm long); the length of the tentacle is abt. 5 mm, the breadth of the plate abt. 1.7 mm. The growth of the median part has now become considerably slower than that of the lateral portions; the median point, for instance, is now much shorter than the lateral lobes; of these, 7 are now developed on either side. The pigment is but poorly preserved; we can, however, discern the transverse belt before mentioned. The figure shows how the plate with the lobes in the preserved specimen are folded forward over the terminal process. The tentacle of a small bottom stage (65 mm) is abt. 6 mm long and has 11 lateral lobes on either side. The tentacle of an adult specimen abt. 166 mm in length is abt. 22 mm long; it shows the above characters somewhat indistinctly; the lateral portions of the plate have grown considerably, be much folded, and have on either side abt. 20 lobes, the longest abt. ¼ the length of the plate itself; the median portion is also only abt. ⅓ as long as the plate. The pigment has spread over the whole of the plate and lobes; but the mentioned belt is still distinctly visible.

Among earlier writers, Düben and Koren (1846) have shown the tentacle of a very young *Lophius* (78 mm) from North-European waters; the figure (Plate III, fig. 3) agrees as an intermediate stage between the small bottom-stage of 65 mm. and the adult specimen of 166 mm. (Cf. also Fulton, 1903 p. 188; description of the tentacle of a small bottom-stage, 124 mm). All the postlarval specimens examined agree

[1] As an exceptional case, we find, in one specimen of 27 mm, the tentacle very nearly 2 mm long, and with 2—3 pairs of lateral lobes (S. W. of Ireland).

entirely both as to length and shape with the foregoing, and the variation frequently mentioned in the literature as occurring in adult specimens, and possibly due to regeneration (Günther, 1861) is not found in the postlarvæ.

From the figures in Stiasny (1911) it will be seen that Adriatic specimens have a tentacle much longer than that of North-European specimens of similar size; the structure in detail is not shown. The tentacle of the American *Lophius* is long; in a specimen of total length abt. 36 mm, it is 7 mm, as against abt. 2.5 in the North-European, and the shape also is quite different (Fig. 13). The tentacle plate of the North-European form is discshaped, with a dorsal carina and concave in front, whereas in the American form, a transverse section appears almost in the shape of an equilateral triangle, but the dorsal carina and the concave front are distinctly apparent.

We may briefly note the development of the tentacle in the American form:

6.5 mm: D_1 I a small process in the sub-epidermal space at base of D_1 II. 7.5 mm: D_1 I not yet reaching to the outer contour. 10.5 mm: D_1 I forms a small process in a hollow just in front of D_1 II. 12—14 mm: D_1 I is abt. 0.5 mm long, with a thinner "median point" (abt. 0.18 mm long) set off from it. 16 mm: D_1 I abt. 1 mm long, (abt. twice as long as in the North-European form of same size). 36.5 mm: the tentacle is now 7 mm long and reaches far beyond the posterior margin of the eyes, which is not seen in any of the North-European specimens. As shown in Fig. 13, the shape is entirely different from that of the North-European form, as also the pigmentation. The "median point" here possibly homologous with the median point in the North-European; it would seem, however, more correct to regard it as a lobe, while the dorsal carina runs out into a much shorter median point (Fig. 13); at any rate the pigment along the edges of the foreside runs out in the long "median point", while the pigment of the dorsal carina is not in any marked connection with that of the "median point". The lateral lobes are still small and alternating (this is not conspicuous in the North-European, but seems nevertheless to be so, as a matter of development).

Fig. 12. First ray in the anterior dorsal fin. *Lophius piscatorius*, L., 60 mm (1903). Fig. 13. First ray in the anterior dorsal fin *Lophius americanus*, Val., ca. 36 mm. (The mark indicates 1.5 mm; anterior and lateral view), (1922)

Later development is unknown; we cannot say whether the lateral part grows out, making the tentacle bilobate in the adult specimens, as is the case with the tentacle plate of the Adriatic form[1].

The Pacific *Lophiomus litulon* (Jordan) seems (according to Tanaka, 1916) in its older stages to preserve D_1 I as not bilobate. The same would appear to be the case with a postlarva (of *Lophiomus spilurus*, Garman?) from the Bay of Panama, whereas postlarvæ of *Lophiomus caulinaris*, Garman, from the same locality show very powerful development of the median point, but also small lateral lobes.

The skin fragments along the lower jaw and over the gill cover etc. are developed late in the North-European form, the earliest indications appearing at a length of abt. 20—24 cm. When the postlarva is 20—24 mm, we find indications of a few skin fragments in two rows across the inner side of the pectoral fin, at a length of abt. 25 mm the above mentioned skin processes in the pectoral fin are more distinct; and further, we now find along the lower jaw and over the gill cover a row of small processes; al

[1] G. Fritsch (1884) states that Smyrna specimens of *Lophius* often had "worm-shaped" tentacle head, whereas spec from Naples and Trieste were generally of the lobed variety. Cf. also Goode & Bean, 1896, Pl. CXVIII, fig. 400; the specimen shown seems to have undivided tentacle head.

the 2.—4. ray of the anterior dorsal, also, small processes are seen where these rays' first appendices grow out. Abt. 30 mm: the pectoral fin shows now, apart from the two mentioned rows with several skin-tags, also a more irregular row between the two mentioned; along the lower jaw and on the gill cover, more fragments have appeared; in D_1 they are now seen on the 2.—5. rays, largest on the foremost rays; on the fin-integument of D_2 a single one has appeared. Abt. 35—40 mm: no. of fragments increasing, and divided into an oak-leaf shape; scattered over the gill cover, the head, on the caudal part of the body, and on the fin-integument of D_2 a few are indicated. Abt. 45 mm: The tags increased in number, size and ramifications at all the mentioned places. 60 mm as above, but indications now apparent in D_1 VI, and along the caudal part of the body, the fragments are especially distinctly in two rows (fig. 8).

Spines on the head appear in the postlarvæ of the North-European and American forms to begin calcination at an early stage (less than 15 mm). On comparing the American specimen of 36.5 mm with specimens from Northern Europe, however, we find, as with other characters, that the spines are more developed in the American than in the North-European form at the same length. In the former, the points of the pair of spines just behind the eyes, as also those of the pair nearer the median line than the latter and just behind D_1 III, project about 1 mm beyond the epidermis, and are very distinctly visible. In the North-European form, the last-mentioned pair of spines has, at a total length of 60 mm not yet reached out to the epidermis.

The teeth are formed early; as opinions in extant literature are divided on this point, I will mention that the North-European form at a length of 9.8 mm has two teeth in the upper mouth with the points projecting beyond the epidermis. In accordance with the more rapid development generally of the American form, we find this with a pair of teeth both in the upper and lower jaw at a length of only 6.5 mm.

Numerical characters. The number of vertebræ is stated for European specimens as 25—32; we should point out, however, that the specimens from which these figures are taken are not as a rule very precisely localised, so that further investigation of the point would be desirable. Valenciennes (1837) considers the species *L. piscatorius* and *L. budegassa* as identical, and gives the no. of vertebræ as 25—31. Günther (1861) gives for the former: 28—31, and for the latter 27—30; Carus (1889—93) 28—31 and 25—26 respectively. Malm (1877) mentions among North-European specimens two with 32 and 3 with 30 vertebræ; Lilljeborg (1891) gives for a North-European specimen 30 vertebræ; a specimen from the Kattegat examined by us had 31 vertebræ. The mentioned seven North-European specimens had thus 30—32.

With regard to other numerical statements in the literature, matters are no better than with those just quoted; D_2 for instance, is recorded as having from 8—13 rays. The specimens from Northern Europe examined by us had: D_2 11—13, A 9—11, P 24—27 (V always 6, C always 8 and always 6 branchiostegal rays)[1]; Malm (1877) gives for North-European specimens similar figures (D_2 11—13, A 10—11, P 26). It is therefore possible that the low numerical values will be found to apply to one of the possible two Mediterranean forms.

Numerical values of the American form[2] as given in extant literature are possibly quoted from European works. The few investigated by us had however: Vert. 28, D_2 11—12, A 9—10, P 27 (V, C and Brr. always the same value as the European).

The ova of *Lophius* have been described by several writers. For purposes of comparison with the size of the ova measured by Bowman from North-European waters, we give here the sizes of ova in the American form. These were obtained from the Labrador Current a little to the north of Cape Hatteras

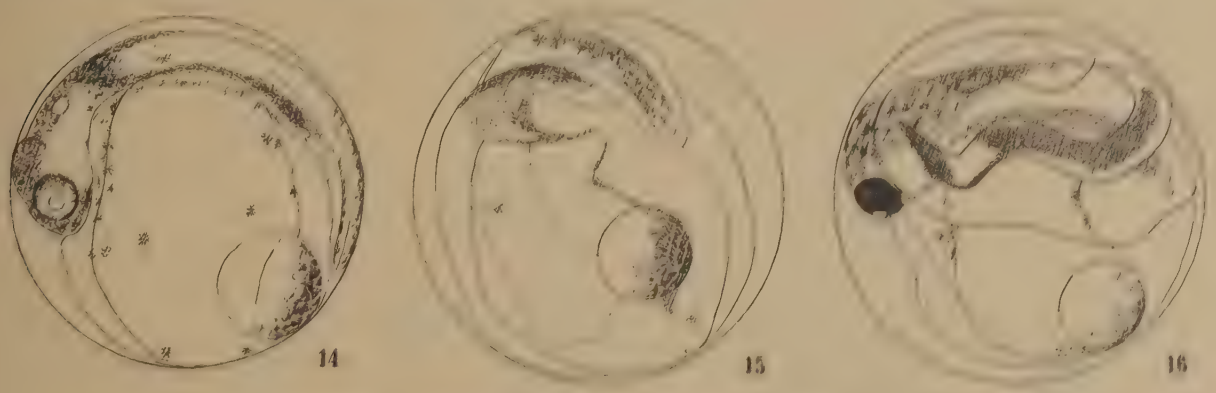
[1] No. of rays in 25 larger postlarval stages: D_2: *12*: 16 specimens, *11*: 9; A: *11*: 7, *10*: 16, *9*: 2; P: *27*: 7, *26*: 13, *25*: 4, *24*: 1.

[2] As we know, the Pacific forms (*Lophiomus* and *Chirolophius*) have much lower numerical values than the Atlantic forms: Vert. 18—20, D_1 3—6, D_2 7—9, A 5—9, P 15—22).

(see also p. 25) and have been preserved for abt. one year in 4 % formalin. The eggs measured are at the stage of development shown in figs. 14 and 15. Length of diameter varies from 1.53 to 1.77 mm, and the oil globule is abt. 0.42—0.45 mm. BOWMAN shows that the egg of *Lophius* is slightly oval; the same applies also to these from the American coast, the difference between the mean values of the two diameters taken at right angles being abt. 0.05 mm.

AGASSIZ and WHITMAN (1885) give the size of the egg as 1.75 mm, and the oil globule as 0.40—0.42 mm. BOWMAN finds the size of living eggs between 2.04 and 3.11 mm in the North-European form; a sample of formalin-preserved eggs ranged in size from 2.1 to 2.9 mm and the oil globule in these was 0.52—0.88 mm.

It is thus evident that the ova of the American form are considerably smaller than those of the North-European form. The few, evidently newly spawned ova of the American form which we have seen show that the eggs of this form, like those of the European, often have several oil globules at time of spawning; in course of development, these globules fuse into one large one, often, however, with one or two quite small ones at the side.



Figs. 14—16. Developmental stages of *Lophius americanus*, Val. (1922).

We will then proceed to consider the earliest stages of the American form, as a comparison between these and the North-European is of importance.

AGASSIZ has described the eggs and smallest stages of the American form, as also a single specimen of 30 mm; he gives, however, only the measurements of the last-named specimen, and makes but brief mention of the very important larval and post-larval pigment; it will therefore be worth while, for purposes of comparison with the North-European form, to learn something more as to the degree of development at the various lengths as also the distribution of pigment and mode of formation.

A couple of eggs with embryos somewhat younger than AGASSIZ' youngest, Pl. VI, fig. 1 (1885), show that the American, like the North-European form, has pigment as soon as the embryo begins to shape. The caudal pigment separates gradually from that in front, and when the caudal point is free, and the eye commencing to show pigmentation, the distribution of pigment is then as shown in figs. 14 and 15. Dense pigmentation runs along the dorsal side of the head and down in front over the fore-end of the embryo, as also a little in on the ventral side (in course of growth, this pigment does not come to lie on the ventral side of the head); the medullary groove is unpigmented, but the pigment later spreads out also over the posterior part of the brain, from behind and from the sides, as the medullary groove closes up; behind the auditory organ, the pigment spreads down towards the ventral side and thus connects with that along the alimentary canal; this connection is later interrupted (fig. 17). The vitellum has dense pigmentation in towards the embryo, running partly a little down the anterior side of the vitellum and partly towards the very close pigment around the oil globule (fig. 15); this last, however, may at times

be much darker than shown in the figure. Scattered chromatophores are found over the vitellum. The caudal part of the embryo is strongly pigmented, and the pigment is coherent, not broken up into several transverse bars. The eye has begun to show some pigmentation.

The figures (16, 17 and 18) show that the body pigment does not undergo any essential change until the larva is hatched and ready to emerge from the mucus, the caudal pigment on the other hand, undergoes an interesting change, dissolving into three transverse bars. fig. 16 shows how the tip of the caudal pigment is pushed off from that in front, fig. 17 how this again breaks up into two bars, and fig. 18 gives the hatched larva (4.5 mm long) with these peculiar, strongly marked pigment

17

18

Fig. 17. Embryo of *Lophius americanus*, Val. 3.3 mm (1922). Fig. 18. Newly-hatched larva of *Lophius americanus*, Val. 4.8 mm (1922)

bars. The eye is pigmented already while in the egg, at a relatively early stage. The first formation of the second ray in the anterior dorsal fin is also visible at an early stage (fig. 16).

We may at times find a chromatophore just at the tip of the notochord; in a few of the hatched larvæ, a detached chromatophore may be observed between the two foremost bands of pigment, or in front of the foremost, or in both places (among 220 specimens, however, there were only 10 with these variations). Agassiz mentions a third caudal pigment spot, situate somewhat more to the front than the foremost here mentioned[1]; this we have not found in any of the great number of specimens examined.

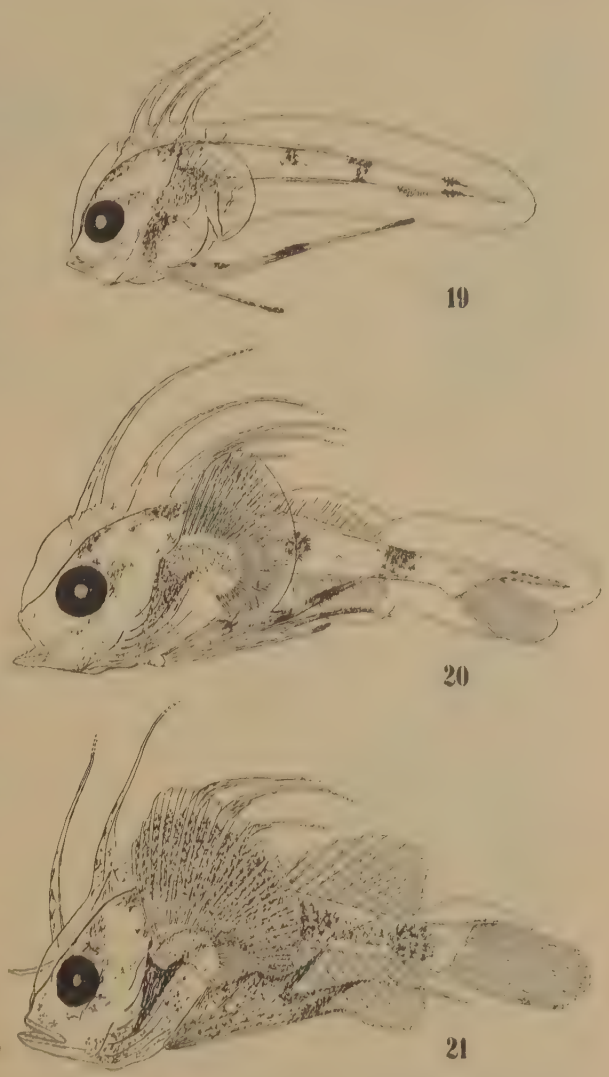
We have mentioned the pigmentation of these young stages in some detail, as the American form here shows a marked difference from the North-European form, which does not begin to show caudal pigment until after leaving the egg. As will be apparent from several points in the following, there are altogether so great differences between the North-east and the West-Atlantic forms, that

[1] Cf. Williamson 1911, Plate II, fig. 2, where a newly hatched larva of the North-European form shows a pigment spot answering to that mentioned by Agassiz (1882). Both forms have very faint pigment in the caudal part of the embryonal fin-fold.

it will hardly be unwarrantable to maintain the latter as a distinct form (*Lophius americanus*, Val.). The Mediterranean form will possibly agree in regard to pigmentation, as in several other respects, with the American (according to STIASNY's text and figs. 1911).

The three larval pigment bars mentioned above are very visible in all the stages we have up to abt. 16 mm of the American form (see fig. 21 and cf. also STIASNY 1911, Pl. 1, fig. 3—7 and 9 (12—23 mm) which also show these pigment bars).

AGASSIZ mentions that the pigment bars had disappeared in the largest of his specimens (30 mm); this agrees with the fact that in our largest specimen (36.5 mm) the bars are effaced from the postlarval pigment, which has now greatly increased; in this larger specimen, as also in older North-European specimens, the pigment is strongest in the abdomen, on the body above and just behind the pectoral fins, and on these and the ventral fins. The posterior larval pigment bar, which lies about the tip of the notochord, is, however, still present in the form of small melanophores in the specimen of 36.5 mm.



Figs. 19—21. Postlarval stages of *Lophius americanus*, Val. Fig. 19, 6.5 mm; fig. 20, 10.5 mm; fig. 21, 16 mm (1922).

While the body pigment in the North-European postlarva seems in the main to have a distribution closely corresponding to that of the American form, the caudal pigment is not indicated until after the larva has emerged from the ovum (cf. ALEX. BOWMAN p. 7 f., M' INTOSH 1892, Pl. XIV, fig. 13, and WILLIAMSON 1911, Pl. II, fig. 6). BOWMAN mentions the first caudal melanophore in a larva of 5.5 mm. At a length of abt. 9—10 mm we still find only small melanophores at the later upturned tip of the notochord (this pigment thus answers to that part of the embryonal caudal pigment in the American form which first separates off from the anterior part of the caudal pigment, cf. fig. 16).

Not until the postlarva is abt. 11 mm long are the two anterior caudal pigment bars formed; the foremost under the forepart of D_2, the hinder just behind the caudal end of D_2 and A (and first of them?); as mentioned, these bars are differentiated in the American form while still in the ovum, when the embryo has attained a length of abt. 3.3 mm.

At subsequent stages in the North-European form, the three caudal pigment bars are distinctly separated; at a length of 16—20 mm, however, the bars begin to fade, owing to the formation of melanophores all over the body and on the tail; but even at a length of 32 mm the three caudal bars are still discernible.

The American postlarva of *Lophius* fits in extremely well with the series of Adriatic postlarvæ described by STIASNY. STIASNY's smallest specimen, 10 mm, corresponds very well with the American specimen of this length, in point of development. Some slight divergencies are, however, to be found; as for instance, when we read that the Adriatic form has no teeth until a length of 17 mm, whereas the

American form gets its teeth fairly early (see p. 12). The tentacle (D_1 1) has in American specimens of 16 mm, only its terminal point as yet set off, not the distal plate itself, which Adriatic specimens are stated to have already at 15 mm; these latter have at a length of 19 mm, indications of bilobate distal plate, but unfortunately, no further description is given as to this, (the length of the tentacle, on the other hand, agrees in the two forms). The skin-tags on the lower jaw and over the gill cover appear to be developed earlier in the Adriatic than in the American form; in the former, they appear as small processes at 18 mm length, whereas our specimen of 36.5 mm only shows these skin fragments as scattered, short formations, not yet exhibiting the oak-leaf outline. It is interesting to note that both the Adriatic (STIASNY, 1911, p. 13) and the American form have no skin-tags on the rays of the anterior dorsal, whereas these formations are found there in the North-European form at a length of abt. 25 mm. Possible these formations are lacking altogether in the adult American and Adriatic *Lophius*, and the remaining equipment of skin-tags in the former is possibly far less developed generally than in the North-European (cf. GOODE & BEAN 1896, Pl. CXVIII, fig. 400). GÜNTHER's figure, on the other hand, of a specimen from Messina (1861), resembles in regard to these characters the North-European form, and we should therefore bear in mind that ontogenetical studies may possibly lead to a decision as to the correctness or otherwise of establishing two Mediterranean species, one of which would then possibly be specifically — not racially? — identical with the North-European form. According to the material at present available, we can only assert that these postlarval characters may fairly be regarded as of systematic importance.

BIOLOGICAL OBSERVATIONS.

A. Horizontal distribution of ova, postlarvæ and small bottom stages.

Our knowledge of the ova of the European species is mainly derived from floating mass of spawn washed up on shore — or carried near there — along the coasts of Southern England and Scotland. Some few finds have been made out at sea in Scottish waters, and in this connection, ALEX. BOWMAN's investigations as to occurrence of isolated eggs should be particularly noted; even outside Trondhjem Fjord a mass of spawn with undeveloped ova was observed (K. DAHL, April, 1898) and E. EHRENBAUM (1905—09) records isolated eggs from the Skagerrack in July.

As will be apparent from the distribution of postlarval stages, the spawning area indicated by the finds of ova is not illustrative of the area to be taken as the principal spawning region of the species; and it must therefore be a task for the future to discover the easily recognisable eggs in the places where they must occur in great numbers.

The larvæ live for the first part of the time in the gelatinous mass of the spawn, as our investigations with the American form show. In the collections from North-European waters to which we have

	Depth in metres				
Length in mm-groups	< 100	100—400	400—1000	1000—2000	> 2000 m
50—60	..	..	..	1	1
40—50	..	..	..	3	..
30—40	..	2	1	13	3
20—30	..	1	2	19	1
10—20	4[1]	15	26	54	9
7—10	11	11	6	6	3

[1] All specimens smaller than 13 mm.

had access, there were no specimens of the earliest larval stages, which are doubtless in the great majority of cases destroyed by the fishing implements used, as is the case with most oceanic fishes.

The chart (Fig. 22) shows localities of capture for postlarvæ in North-European waters, and we shall in the following consider more closely the individual areas were postlarvæ have been found.

1. As the principal area we may take the Continental slope west of Europe from a little north of 60° to abt. 48° N. Lat. Small stages were not found north of abt. 61° 50′. The "Thor" made only a few investigations directly west of Ireland, and the area is therefore in our collections (though hardly in reality) divided into a northern and a southern, WNW. of Scotland and SW. of Ireland.

The northern part of the principal area (north of abt. 55° and west of Long. 6°) has been well worked over, and have yielded abt. 125 specimens; the stock of *Lophius* in the North Sea doubtless originates almost entirely from here.

A survey[1] of the distribution in regard to depth curves (p. 16) shows that while some, for the most part small stages, are found inside the 400 m limit, the great majority were taken between this and the 2000 m line, including here both small, and nearly all the larger postlarvæ. The captures appear to lie grouped more particularly about the 1000 metre limit; this, however, does not of course definitely imply that the spawning fish keep to this line, as the current may have carried the spawn and small postlarvæ some distance out from the actual spawning grounds, and the isobaths in the area run close together. It is hardly likely, however, that the bulk of the spawning fish would come far inside the 400—1000 m limit.[2] Outside the 2000 m line, as the lists

Fig. 22. Distribution of postlarval stages of *Lophius piscatorius*, L., (○ ●) according to the investigations of the "Thor" 1903—1908. ● Postlarvæ > 30 mm. — Postlarvæ taken in July—September. The curves of depth in metres (1000 and 2000 metres).

[1] Here, as in the later summaries, we must refer to the lists p. 27 f. where details of the hauls are given. The material is too small to admit of precise calculations as to no. per hour per depth, etc. and the figures generally must be taken with some reserve. The above survey comprises all our available material.

[2] Adult *Lophius* have been taken on the Færoe Bank, Lousy Bank and the Rockall Bank.

show, less fishing was done, but such stations as we have here do not appear to suggest that the young fry are to be found in any great quantity above the greater depths; we cannot, however, fix any exact limit to the westward. Possibly the postlarvæ, during the course of their development, move out from lower into somewhat deeper water.

The two largest pelagic stages we have, 56 and 60 mm, were both taken up towards Iceland, they probably hatched out farther to the southward, and had made a journey of many miles since then.

2. The Area north of Scotland and into the North Sea proper (The Scottish Area) next calls for special mention.

Our material from here falls especially to the months July—September; the specimens are from 7—17 mm, but a couple taken in July directly to the west of the Orkney-Shetland Islands, measure abt. 30 mm. Two specimens were taken in May due west of the Orkney-Shetlands; one of them is 10 mm. long, the length of the other is unknown (see p. 29)

All previous captures from inside the Orkney-Shetlands are entirely in agreement with our own, and all that is known of ova and young fry north-west of Europe is from here. The following table, compiled from Alex. Bowmans work, gives a survey of this material:

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
No. of hauls yielding isolated eggs	..	1	9	12	2	3	4	..	..	..	..	..
Records of spawn	..	1	..	..	1	..	5	1[1]	..	..	..	..
No. of postlarval stages	..	..	..	..	..	..	23	8	1[2]	..	..	..

[1] 1—8—01. [2] 11—9—09.

It will at once be noted that the postlarvæ (all less than 17 mm) were only taken in July—September, while the isolated eggs were taken in greatest quantities earlier, in March—April. Most of the floating spawn were taken nearly at the same time as the postlarvæ. Nearly all the ova were more or less developed; there are, however, also some almost newly spawned (from as early as February onwards).

Here, then, in the Scottish area, we note that spawning takes place from the earliest spring, and that only postlarvæ of under 17 mm were found inside the Orkney-Shetland Islands, but late in summer, and later at any rate that the bulk of the isolated eggs.

As shown by Dr. Johs. Schmidt in 1905, as later by others, there is often in the summer a stronger inflow of Atlantic water and with it of organisms, round the north of Scotland. The occurrence of postlarvæ here seems entirely to coincide with this (see Schmidt 1909, p. 159, fig. 15). The agreement with the facts pointed out by Johs. Schmidt is here, however, in regard to occurrence of *Lophius* ova and postlarvæ only apparent, or partial. Alex. Bowman has shown that spawning takes place also in the first weeks of July in the Scottish area, and we must doubtless suppose that a great part of the eggs found in the Scottish area from early spring onwards were not carried in by the current. The same doubtless applies to the ova reported by E. Ehrenbaum in the Skagerrack in July and K. Dahl's find outside Trondhjem Fjord in April.

The question to be answered then, is why no postlarvæ are found in the Scottish area inside the Orkney-Shetlands early in the year, when eggs — and some even in the hatching stage — are met with there, and in April, even a few small larvæ (see A. Bowman p. 28); also, why no postlarvæ over 17 mm were ever taken inside the mentioned limits, when considerable fishing was done there.

Presuming our material to be representative, we may take it that the explanation is as follows:

When the emigrant *Lophius*, approaching maturity, meet the inflowing Atlantic water north of Scotland, this leads some of them to spawn (as to whether they produce eggs not assembled in band of

mucus, we cannot say; the isolated eggs found might well have been detached from the mother-colony after spawning). The early-spawned ova in the Scottish area inside the Orkney-Shetlands can attain to the hatching stage, and the larvæ can emerge, but are evidently then at a stage where the natural conditions of the water destroy them. Later in the year, when the water here is more oceanic, a more intensive spawning — and more normal? — takes place, and the larvæ then reach the postlarval stage[1]; they only attain, however, to a small size, and die off, owing to the fact that the natural conditions do not fulfil their requirements for attaining metamorphosis (depth possibly not great enough, or the season too far advanced, cf. p. 25).

3. Area at the mouth of St. George's and the English Channel.

This area can doubtless in its way be taken as parallel with that just noted; at any rate, only a few quite small postlarvæ (7—9 mm) were taken here (in May—June) and these somewhat stunted in length compared with stage of development (cf. specimens from the Bay of Biscay). We must suppose that they do not attain very far in their development; older postlarval stages are not known from here; as, however, true oceanic forms such as for instance the fully grown postlarvæ of *Conger vulgaris* have been taken at Cape Gris-Nez, it is possible that also larger postlarvæ of *Lophius* may in certain years be found here occasionally. The majority, however, will probably not be met with here until they have reached the bottom stage.

4. Bay of Biscay. Only in the inner waters of the bay were postlarvæ found (9 spec. 8—14 mm long); they were taken mid-May, are small, and the only ones known from the bay at all, neither "Thor" nor "Dana" having found them farther out in the Bay, and none are mentioned in other works from here. The specimens fall, in regard to length and development, altogether outside the series formed by those from S.W. Ireland and farther north, but answer well in point of development to specimens of corresponding length from the Adriatic, Stiasny, 1911; this applies also, for instance, to the length of tentacle. These specimens have lost their pigment in course of time.

It should be added that specimens from S. W. Ireland in all main characters agree entirely with those found farther north, not with the few here found.

The Bay of Biscay evidently represents the southern limit of the spawning area for the North-European form, or the northern limit of one of the possible two Mediterranean forms (abt. 45° N. is the limit for several species or races of fish). This, however, could only be decided by investigations embracing also larger postlarvæ and adult stages, as the discrepancy between the small specimens from here and those from the principal area farther north might be due to natural conditions here in the south affecting the growth in length, but not the stage of development of the organs otherwise.

Having now dealt with our available material of postlarval stages, we can proceed to consider briefly the small bottom stages of between 60—100 mm.

These are little known, and we may take it as chiefly due to the fact that the great majority are found out towards the 1000 m limit, not coming into the waters where they are fished until after reaching a size of 125—200 mm. Only about a score of specimens under 100 mm are known from North-European waters.

All the localities distinctly show where the origin of the specimens lies, the finds being so grouped as to radiate from the main spawning area W.N.W. of Scotland, as will be seen from the list given below which probably includes all that is known.

[1] Development under the somewhat altered natural conditions to which postlarvæ in the current north of Scotland are subjected may perhaps retard development considerably. Cf. H. C. Williamson 1911, p. 46—47 and fig. 9 compared with fig. 6, showing that small postlarvæ can live for abt. 2 months (in an aquarium) without undergoing any marked change; abt. one week is enough to give nearly the same degree of development (fig. 2 compared with fig. 9).

Iceland	Westman-Islands	Cast ashore	Date?	91 mm	(B. Sæmundsson)
	63° 42′ N. 17° 34 W.	Depth 70 m	$^{19}/_{7}$—03	65 —	("Thor")
Norway	Off Stavanger	Cast ashore	? —34	94 —	(Dūben & Koren)
	Christiansund	—	$^{11}/_{9}$—43	78 —	(— —)
	Off Bergen	—	$^{21}/_{8}$—07	85 —	(James Grieg)
Scotland	58° 44′ N. 7° W.	108 m	$^{11}/_{7}$—06	67 —	("Goldseeker")
	— —	—	—	64 —	(—)
	59° 4′ N. 7° 4′ W.	182 m	$^{12}/_{7}$—06	72 —	(—)
	— —	—	—	83 —	(—)
	60° 45′ N. 2° 30′ E.	129 m	$^{4}/_{9}$—06	69 —	(—)
	Moray Firth	42—44 m	$^{14}/_{10}$—11	94 —	(—)

F. Guitel (1891) mentions a specimen of 90 mm, probably from Roscoff, and thus radiating from the area S.W. of Ireland. Valenciennes (1837) mentions a small specimen from Le Havre; this, however, is over 100 mm (abt. 135 mm). Otherwise, I have not found anything relating to small bottom stages from the Irish area. It would be very desirable altogether to have bottom fishing-investigations carried out with suitable implements at those localities where the stages in question must at certain times be found in great numbers.

B. Vertical Distribution.

Alex. Bowman states that the floating spawn are most frequently observed a little below the surface. The eggs taken by the "Dana" in 1922 at Cape Hatteras were brought up with 25 and 50 m wire, i. e. taken at a depth of abt. 10—25 metres; they varied somewhat in regard to stage of development, the youngest stages being taken deepest down.

Most writers express surprise that the eggs are not more often found in North-European waters than has proved to be the case; from our present knowledge as to the spawning grounds of the species, however, we can hardly expect frequent observations of floating spawn on this side of the Atlantic; on the coast of North America, where the hydrographical conditions close inshore are so widely different from those of Europe, such observations are evidently far more frequent; as it would seem, of eggs as a rule at an advanced stage of development. The North-European centre of spawning lies, however, so far west of Scotland and Ireland that very few marine biologists have ever been there at the right time (abt. March—May).

Such spawn masses as are better known were advanced in development — with one exception, sticking to a trawl net (3/5/1916, Bowman), and most writers state that these masses were taken a little down in the water. It is not likely that the eggs could drift far in the short time required for development of the embryo. We are inclined to suppose that the newly spawned egg-bands float near the bottom, and this agrees entirely with the whole gelatinous structure of the egg-colony, which may be compared with the deep-sea pyrosomes of gelatinous, fragile structure some 2—3 metres long. Such colonies as the great deep-sea pyrosomes and the enormous egg-bands of *Lophius* could hardly, from a phylogenetic point of view, have come into being near the surface of the sea, with its varying currents and wave movement, which would soon split up the mass into individuals units; the origin must rather have taken place under quieter conditions such as would be afforded by the depths of the ocean. We must therefore doubtless presume, as far as regards the spawn-masses of *Lophius*, that they ascend, during process of development, up towards the water layers where the larva is destined to emerge — and once the development has reached this stage, it is only an advantage that the movement of the surface water should then dissolve the colony. The larvæ keep for a time to the muscus; when they leave it, they are perhaps near the surface. Bowman has taken 3 specimens at the surface, but whether they are always found here we cannot say.

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A glance at the accompanying table showing lengths of wire with which postlarvæ were taken, decidedly suggests that most of the postlarvæ are not found very close to the surface, but at depths worked with 60—300 m w., i. e. from 30—150 metres down.[1] It would seem, however, as if the smallest stages (less than 10 mm) keep somewhat higher up than the larger ones. The larger stages appear to move downwards, but it is remarkable that our two largest specimens were taken near the surface. Both were taken up towards Iceland, but whether this northerly locality counts for anything in this respect we cannot say.

	Metres of wire out			
Length in mm-groups	10—25	60—120	200—300	> 350 m. w.
50—60	2	..	..	..
40—50	..	..	3	..
30—40	1	6	12	..
20—30	2	8	11	2
10—20	9	52	42	5
7—10	11	20	2	1

As will be seen from the lists p. 27 f. the "Thor" did not in all years fish very much with over 350 m wire; there is, however, nothing to suggest any greater abundance of larger postlarval stages at this depth (cf. 1906 p. 29). In regard to several characters, our largest specimen seems to suggest that the metamorphosis takes place gradually; possibly, however, the reduction of the large sub-epidermal space which covers practically the whole of the body proceeds comparatively rapidly and in relation to this, transition from pelagic to benthonic life may also be rapid. After all, we do not know with any certainty where individuals in full process of metamorphosis congregate. Adequately preserved undamaged specimens at this stage of development, taken for scientific purposes, do not, as far as we are aware, exist at all. (Stiasny's specimens (1913) were procured under exceptional conditions, and will not serve to decide the question).

The small bottom stages of 60—100 mm have been so rarely taken that we must presume most of the finds to be due to exceptional occurrence. Four of the 11 in the list p. 20 for instance, were found washed up on shore, or just at the margin of the water, evidently outside their normal haunts. The remaining 7 were taken in 42—182 metres of water; four taken by the "Goldseeker" N.W. of Scotland at two stations not more than abt. 35 nautical miles from the 1000 m limit must be regarded as taken at or near the normal site for such stages — and they distinctly show that these small stages come from the deep water outside, where their earliest development takes place. In the main area only little fishing has been done with bottom-working implements at suitable depths, and for the most part probably with nets of a mesh diameter which such tiny organisms would easily pass through.

We must presume that the small bottom stages, shortly after moving down to the bottom, commence their migration in towards shallower water; the majority do not reach localities where they are fished until several months later, and are by that time already abt. 12—15 cm or more.[2]

[1] Stiasny (1911, p. 15—16) has very clearly explained the remarkable phenomenon presented by the occurrence of *Lophius* postlarvæ right in to Trieste. During cold winters, after the off-shore wind (the "bora") had been blowing for some days, there were *Lophius* at the right season; in the warm winter of 1909—10 when the "bora" was not blowing, none were found. This shows that the postlarvæ, (and especially the older ones; most of Stiasny's material — abt. 86 % — was over 20 mm) keep to the intermediate water layers. Stiasny never took *Lophius* postlarvæ in the open sea outside Trieste; this was probably due to their being found farther to the south in the Adriatic, over greater depths. Possibly the requirements of the Adriatic form in regard to depth are different from those of the North-European form.

[2] Immigration into the waters of the Skagerrack, the Kattegat etc. is of interest in this connection. Malm (1877, p. 467) states that he has found specimens up to 132 cm off the coast of Bohuslän, but never any of less than 28 cm; he adds, however, that fishermen have told him of specimens somewhat smaller (down to 20 cm?) which they have seen. This agrees with the information we have from the Kattegat; the smallest specimen from here, 166 mm, was taken in the northern part ($^{10}/_{7}$ 1906, 57° 41′ N., 11° 07′ E.) and must be presumed to have covered the distance from the spot where its metamorphosis took place in about a year. Fulton (1903) states, that the smallest adolescent stages are taken in deepest water in Scottish waters.

Adolescent stages thus move gradually in to the European continental shelf, and shallower inner waters. The majority of those from the northern part of the main area appear to frequent the North Sea. The migration of the adolescent and adult stages is of a multiple character, comprising a food-migration inwards, which is perhaps in some cases not of very great extent (e. g. to Rockall and W. Scotland), in others longer (e. g. to the north of Norway and into Kattegat) — and a seasonal migration, in regard to which we have not sufficiently detailed information. And finally, in the case of the adult stages approaching maturity, there is the great contranatant migration which takes place out to the spawning grounds in deep water in the Atlantic. Possibly some live here all their life.

From this it will be evident that the bathymetrical distribution of *Lophius* cannot be stated in general terms; here, as with so many other fishes, the age, season and degree of maturity have to be taken into consideration.

C. Spawning Time, Growth, etc.

As mentioned, we cannot determine the spawning time in the main area from the finds of floating spawn, we must therefore endeavour to arrive at it from the postlarval material at our disposal. One of the better investigated areas is that portion of the main area which lies west of Scotland (W. of 6° W,); we will therefore from this area take a survey of the material of postlarvæ from all years. As early as May there are, besides quite numerous stages below 15—20 mm, also a few which have reached

Area West of Scotland (West of 6° W. Long.)

Length in mm-groups	No. of specimens in May	June	July	August	September
55—60	..	..	2	..	..
50—55	..	..	..	..	..
45—50	..	2	..	..	..
40—45	..	1	..	..	..
35—40	..	5	..	..	..
30—35	2	6	..	1	..
25—30	..	6	..	3	..
20—25	4	7	..	..	..
15—20	11	16	..	..	..
10—15	34	17	..	..	..
7—10	14	1	..	..	..

Area SW. of Ireland (South of 52° N. Lat.)

Length in mm-groups	No. of specimens in May 1906	August—September 1906
35—40	1	
30—35	..	
25—30	..	
20—25	2	No specimens taken.
15—20	9	
10—15	25	
7—10	3	

a length of 30—35 mm, but none of 45—50 as in June, in which month a decrease in number of the smallest postlarvæ seems discernible. As the largest postlarval stages of fish are always more difficult to capture than the smaller ones, the figures from June really tell us a great deal. In July, unfortunately, only a little fishing was done in the northernmost part of the area, and only a couple of large postlarvæ were taken here, but farther south, we should doubtless find postlarvæ down to a length of 15—20 mm or somewhat less. In August, some fishing was done in the northern part of the main area, only a few specimens over 25 mm were taken at this time; farther south, there are hardly any of the quite small stages now left, and doubtless only a few of the larger. This is borne out by a similar survey of the area S. of 52°, i. e. especially from the waters S.W. of Ireland, from 1906, which shows that in May, there are numerous stages about 10—15 mm, very few over 20 mm. Three months later, when the "Thor" was working extensively on these grounds, not a single postlarval stage was found, which we must take to mean that the postlarval period of existence comes to an end (even for stages of 7—15 mm) in less than 3 months.[1] This last survey, however, also shows, with a single stage of 35 mm (taken 30. May) that spawning, as also farther northward in the main area, must have begun considerably earlier than in May. (From the area S.W. of Ireland we find in June firstly a couple of intermediate sizes abt. 30 mm, and further, a couple of quite small postlarvæ of 10 mm, thus showing that spawning does not end till some time in May—June).

The entire absence of postlarvæ in August—September in this southern area, while the northern area can still show some, shows that *Lophius*, like several other species, ends its spawning here earlier than farther north. We do not know, however, when spawning begins in the southern area. Here again, in connection with the foregoing, we may call to mind the very late spawning north of Scotland and up in the northernmost part of the North Sea.[2]

Judging from the available material of postlarvæ from the area W. of the British Isles, we are led to place the spawning period here as more particularly in the months of March—May. Farther to the north, spawning lasts longer, especially north of Scotland.

We have already referred to the small bottom stages of abt. 60—100 mm from the northern area (p. 20). The question now is, how do these and larger adolescent stages living on the bottom fit in in point of time, and thus also age, with the mentioned material of postlarval pelagic stages?

We must first mention that Alex. Bowman has from various observations arrived at the conclusion that the small bottom forms are at least a year older than the postlarvæ taken simultaneously with them in the northern part of the spawning area of the species. From the material at his disposal, Bowman could come to no other result.

A casual glance at the accompanying table, based partly on material of postlarvæ from the cruises of the "Thor" in the northern spawning area[3], partly on small bottom forms of 60—100 mm, and finally, a number of larger *Lophius* (especially from the Scottish waters and here chiefly cited after Fulton, 1903) seems to show the continuity in development from the postlarvæ of abt. 1—2 cm in May—June, by way of the smallest bottom stages of 6—8 cm in July—Sept. to the somewhat more frequently captured small *Lophius* of abt. 20 cm the following year in May—June; these last should then be only a little over a year old.

If, on the other hand, we take the small bottom forms as being well over one year old about August, and attribute the fact of their being captured exclusively in July—October to other causes (e. g. currents etc.) than that lying nearest to hand, viz: that they are not at all to be found in the first half of

[1] In future investigations, however, it should be borne in mind that the postlarvæ, as they approach metamorphosis, might possibly move farther out to sea (westward) and go deeper down.

[2] Cf. for instance the lists p. 28; we also know from Bowman's investigations, that spawning can begin in the Scottish area in February.

[3] Postlarvæ taken east of 6° W., north of Scotland and in the North Sea are noted in parentheses.

Length in cm.	Month: I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I
25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	9	..	..	..	1	1
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	7	3	3	1	2	..	2
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	3	3	1	3	1	..	1
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	4	2	..	..	..	1
	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	11	..	1	2	2	..	1	..	..
20	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1	3	2	..	..	..	3	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	4	3	3	..	3	..	2	..	..
	..	..	..	..	..	..	..	..	..	..	3	..	..	..	..	..	3	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	1	..	..	..	1	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	5	1	1	..	..	..	1	..	1	..	1	..	..	..	..
15	..	..	..	..	..	..	..	..	..	..	4	..	..	..	..	..	1	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	10	..	..	..	1	1	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	1	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	3	..	1	..	.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	2	11	(2)	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	4	13	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1 ..	..	..	..	..	45(1)	33	(1)	(1)	(4)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
< 1	?	?	?	?	14	1	(2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

the year — then the growth must, after the rapid postlarval development, be very slow[1]. Otolith investigations might perhaps be of value here in determining the point. At any rate, it is certain that if the small bottom forms are not found generally in the first half of the year, it is thereby proved that the rapid development exhibited by the postlarvæ is continued in the smallest bottom stages, which would thus be less than six months old (four?).

The brief duration of the pelagic stage agrees with the shorter distance the species has to cover before reaching the area where its period of growth is spent (cf. *Anguilla vulgaris* and *A. rostrata*).

Conditions in the Mediterranean appear, from the statements of various writers — which are, however, but scanty — to agree fairly well with the foregoing, save for the fact, also known in the case of other species, that the spawning period is moved back to the midwinter months, but with a slighter degree of spawning a couple of months before and after, as in the more northerly waters.

[1] Which ill agrees with the considerable size, abt. 2 metres, which *Lophius* attains.

The food of the postlarvæ seems to consist mainly of crustaceans, *Sagitta* and postlarvæ of fish; the smaller specimens, up to abt. 20 mm apparently prefering crustaceans, the somewhat larger ones *Sagitta*, and finally going over to fish fry. Of these last, all we have seen were almost exclusively postlarvæ of *Gadidæ*, *Triglidæ* and *Pleuronectidæ*. The postlarvæ are no less voracious than the adults or *Pediculati* generally; one specimen, for instance, measuring 32 mm total length, contained three *Trigla*-young, each at least 13 mm long; another of 30 mm had 10 *Sagitta* of 10—15 mm; one of 36 mm had at least 2 large young Gadoids, the largest over 20 mm long; one of 56 mm had at least 3 young Pleuronectids of abt. 15—20 mm and besides a mass of disintegrated matter. *Sagitta* may be found in great quantities in postlarvæ of the pacific form, *Lophiomus caulinaris* Garman. Stiasny (1911, p. 15) mentions *Sagitta*, copepods and crustacean-larvæ, with *Sagitta* as favorite.

Area	Stage	Month: VII	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Atlantic	Postlarval Stages	..	..	..	..	..	..	?	?	?	?	×	×	×	×	×	..	..	..
	Small Bottom Forms	..	..	..	..	..	..	..	..	..	..	..	..	×	×	×	×	..	..
Mediterranean	Postlarval Stages	..	..	×	?	×	×	×	×	×	×	..	..	..	..	..	..	..	..
	Small Bottom Forms	..	..	..	..	..	..	..	..	×	×	×	..	..	..	..	..	..	..

The table shows the occurrence of postlarvæ and small bottom forms in the Mediterranean and in the north-eastern Atlantic.

We may then briefly consider the hydrographical conditions in the spawning season, in other words, what are the requirements of the North-west-European *Lophius* in regard to the factors generally determining the spawning grounds of fish as to depth, salinity and temperature. In JOHS. SCHMIDT 1909, p. 114 f. we find the material ready to hand.

As previously mentioned, it will probably be found that the spawning fish are chiefly to be met with out towards the 1000 metre limit; the figures given therefore apply to depths thereabout, in early spring. The minimum salinity should be abt. 35.25 ‰. Maximal salinity seems, owing to the fact that the Bay of Biscay must be regarded as the southern limit of the area, to lie abt. 35.70 ‰. Minimum temperature should be abt. 6—7° C., and maximal temperature will, on the same assumption as for max. salinity, be about 9—10° C.

In the Scottish Area, it would seem that the hydrographical conditions exercise a decisive influence on the larvæ and young postlarval stages up to a length of abt. 16 mm, so that their further continued existence or dying off depends on the temperature and salinity of the water layers in which they live (the upper 100—150 metres of the sea). Minimum temperature and salinity for these will be abt. 7—8° C. and 35.25 ‰; max. abt. 11° C. and 35.60 ‰ respectively.

It is interesting to note in this connection the conditions under which *Lophius* lives in the Labrador-current [1].

Here, at 36° 25′ N., 75° 09′ W., up in shallow water (40 metres) the "Dana"-expedition took on the $^{20}/_{5}$ 1922 at the surface: 6 isolated eggs without indication of embryo, 57 larvæ (4.5 mm long) and 12 postlarvæ (abt. 8—12 mm long); at abt. 10—15 metres' depth: abt. 1 litre spawn, with nearly all the eggs burst, but larvæ (4.5 mm long) still remaining in the mucus, abt. 2200 larvæ (from the mucus?) and 33 postlarvæ (abt. 6.5—16 mm). At abt. 25 m depth: 10 isolated eggs with well developed embryos, 223 larvæ (4.5 mm) and 36 postlarvæ (abt. 7.5—14 mm).

Not far away from here, (at 36° 16′ N., 74° 33′ W.) but over abt. 2000 metres depth, we find, on the $^{21}/_{5}$ 1922, at abt. 25 metres' down, abt. $^{1}/_{4}$ litre spawn with somewhat developed embryos (figs. 14 and 15) and also some few undeveloped (unfertilised?) eggs as in the spawn mass taken on the $^{20}/_{5}$; further, at abt. 500 metres down, one postlarva (36.5 mm); no eggs or postlarvæ were taken, however, at 50, 75, 100, 150 or 300 metres' depth. Otherwise, practically no fish eggs were taken at the stations named.

Since the nets above as well as below that in which the spawn mass at the first mentioned station was taken contained larvæ at the same stage of development, we may probably take it that the spawn mass (doubtless in both cases only a small part of a much larger mass) was taken at the stage where the larvæ leave the mucus.

[1] The find mentioned is probably the most southerly of eggs from the American side; the "Michael Sars" 1910 found eggs as far north-east as 41° 39′ N. 51° 4′ W.

The fauna at the two stations mentioned answered very nearly to that we find at abt. 50—60° N. nort-west of Europe; a little farther east (35° 42′ N., 73° 43′ W.) the fauna was closely related to that of the central Sargasso Sea, i. e. rather tropical.

A Comparison of a couple of adjacent hydrographical stations (see below) will serve to show, in the first place, the great difference in temperature and salinity between the water masses containing *Lophius*-spawn and water masses of a character not suited to the same; also, in comparison with the North-west-European area, that the American form must doubtless have other requirements in regard to temperature and salinity than the North-west-European form. The requirements of this form in regard to depth are possibly also different.

We should further point out that the requirements of the Mediterranean form as to temperature and salinity (and depth?) are entirely different, even though the spawning period in the Mediterranean falls in the coldest period for that water (11—14° C.? 36—38.5 ‰ S.?). For the rest, both time and place for the spawning of this form are so little known that we cannot enter into further discussion as to similarity and dissimilarity of requirements between the different forms. The *Lophiomus* forms in the Bay of Panama again live under altogether different hydrographical conditions.

36° 16′ N. Lat. 74° 33′ W. Long.		Depth in metres	35° 58′ N. Lat. 74° 06′ W. Long.	
T°	S ‰		T°	S ‰
14.60	32.83	0	26.33	36.06
13.14	34.49	25	26.20	36.02
12.37	34.94	50	26.06	36.06
12.00	35.08	100	23.55	36.56
11.29	25.30	200	19.44	36.56
8.17	35.08	300	13.74	35.79
4.96	34.94	500	9.87	35.30
3.86	34.96	1000	4.58	34.98

In the following, we will briefly consider some other species of fish spawning in the north-western waters of Europe, for purposes of comparison with *Lophius*.

As we know, several species or races of fish have their southern or northern limit of distribution abt. 45° N., and we may presume the same to be the case with *Lophius piscatorius*.

Of the Gadoids which have their main spawning centre partly or entirely coinciding with that of *Lophius* we may specially note *Gadiculus Thori* and *Gadus Poutassou*[1] (cf. Johs. Schmidt 1909, 1913).

The spawning area of *Gadus Poutassou*, however, does not perhaps coincide quite so closely with that of *Lophius* as does that of *Gadiculus Thori*, as there is evidently an abundant spawning of *G. Poutassou* in the Bay of Biscay. At the northern stations, both species are evidently very sparsely represented; *Gadus Poutassou* seems also to spawn nearer the west coast of Scotland in great quantities than *Lophius*. In manner of life, the postlarvæ of *Gadus Poutassou* differ from those of *Lophius*, inter alia in having a highly prolonged pelagic existence, so that the pelagic stages of the species are distributed far to the NE., whereas *Lophius* doubtless makes its way to the NE. and E. chiefly through the migration of the bottom forms.

The resemblance to *Gadiculus Thori* is extremely striking; we very often find the two species at the same stations and in the same hauls, and the maximum in numbers at a given place for the one species nearly always shows the maximum for the other. The coincidence of their spawning time is worth noting; it is seen for instance in the fact that *Gad. Thori* in Aug.—Sept. NW. of the Hebrides was represented by a few larger specimens, while the same was the case with postlarvæ of *Lophius*. The distribution of the two species in the Atlantic and the Mediterranean seems also to be identical. Some small dissimilarities are noticeable, however, in the North-European spawning areas, e. g. postlarvæ of

[1] *Molva elongata*, which spawns abt. the 1000 metre line, is altogether a far more southerly form, addicted to warmer and salter water. *Brosmius Brosme*, which spawns abundantly round the Rockall Bank, is a far more northerly spawning fish, spawning in shallower water. *Molva byrkelange* is a more northerly form, which does not spawn on the spawning grounds of *Lophius* SW. of Ireland; its requirements in respect of temperature and salinity are thus lower than those of *Lophius*.

Gadiculus Thori are not so frequently met with inside the 1000 metre limit as are those of *Lophius*; at the mouth of the English Channel and in the Scottish area, *Lophius* seems more numerous than *Gad. Thori*, while the latter is more numerous in the Bay of Biscay.

Among other species of fish which appear to spawn in the same areas as *Lophius*, at any rate to some extent, we may mention *Argentina sphyræna*, L.; the spawning area of this species, however, (Joms. Schmidt, 1918) doubtless lies somewhat closer in to land than that of *Lophius*. The related forms, *Argentina silus* (Ascan.) and *Nansenia grönlandica* (Reinh.) have their main centre of spawning about the Rockall Bank, but these are more northerly forms in comparison with *Lophius* (SW. Ireland to Iceland).

In the case of the Angler, then, as with many other fish, we find that the spawning grounds do not coincide with the area where the immature stages are otherwise found in greatest numbers, the requirements of the species during reproduction being altogether different from those for its period of growth.

Even though the spawning migration of the Angler is not of such an extreme character as that of the eel, it is nevertheless, as will be seen, on the way towards it. And as the eel must be regarded as a deep-sea fish, so also the Angler must be placed in the same category; during the most important period of its life, the spawning time, it moves out towards its place of origin, the warm, salt waters of the deep Atlantic, which its phylogenesis has led it to dispense with throughout the greater part of its life.

LIST OF STATIONS ETC.

At each station the position, date, depth (in metres), duration of haul, metres of wire out, numbers of specimens, and sizes (total-length in millimetres) are noted. The hauls are made with Petersen's youngfish trawl[1]. (Numbers and sizes in brackets = specimens lost, but noted in the fishing-journals during the cruises).

A survey is given for each year, showing how much the "Thor" worked in the various areas (43° N. Lat. to 62° N. Lat.). The boundary between the northern and the southern areas is somewhat arbitrarily fixed at 52° N. Lat. Over depths of less than 100 metres, only a few and small specimens were taken; in the tables, we have omitted the hauls at these slight depths, which thus cuts out most of the hauls made at the mouth of the English Channel, in the Scottish area, and some few others. In the northern area, we have therefore taken 2° W. as the eastern limit for hauls included in the survey.

1903.

Locality and month	Depth in metres				Metres of wire out				Total No.'s of hauls	Total duration of hauls in hours
	100–400	400–1000	1000–2000	2000–	10–25	50–120	200–300	300–		
Færoes to E. Iceland (primo May)	4	4	..	..	4	..	1	3	8	1 1/2
S. of Iceland (primo June)	..	..	12	3	15	..	..	..	15	2 2/3
S. of Iceland (medio July)	..	..	3	..	2	..	..	1	3	1 1/2
E. Iceland to Færoes and Scotland (medio August—primo September)	4	4	..	..	8	..	..	..	8	1 1/2

South of Iceland: St. **90.** 61° 30′ N. 14° 38′ W. 9/8. c. 2000 m. 10 mins. 10 m. w. 1: 13 mm. **165.** 62° 35′ N. 19° 48′ W. 18/7. 1390 m. 20 mins. 10 m. w. 1: 60 mm.

[1] Cf. Joms. Schmidt 1909, p. 173—218.

1904.

Locality and Month	Depth in metres				Metres of wire out				Total No.'s of hauls	Total duration of hauls in hours
	100—400	400—1000	1000—2000	< 2000	10—25	60—120	200—300	> 350		
Færoe Bank to Iceland (medio April)	2	1	..	..	..	3	..	..	3	1
Iceland to Færoes (primo—medio May)	13	5	..	..	16	..	..	2	18	4½
W. of Færoes to Iceland (secundo May)	..	4	11	..	7	..	3	5	15	6
S. Iceland (primo July)	..	..	11	4	5	7	..	3	15	16¾
Færoes to E. Iceland (primo August)	2	4	..	..	3	3	..	..	6	2½
S. Iceland to Scotland (primo Septbr.)	4	6	..	..	2	5	1	2	10	9½

South of Iceland: St. **182.** 61° 32′ N. 17° 57′ W. ¹⁰/₇. > 2000 m. 30 mins. 20 m. w. 1: 56 mm.

S. Iceland to Scotland: St. **288.** 59° 34′ N. 5° 41′ W. ⁴/₆. 105 m. I: 50 mins. 120 m. w. 1: 17 mm. II: 60 mins. 70 m. w. 2: 10, 16 mm. St. **290.** 58° 08′ N. 2° 24′ W. ⁵/₆. 76 m. 45 mins. 90 m. w. 1: 10 mm.

1905.

Locality and Month	Depth in metres				Metres of wire out				Total No.'s of hauls	Total duration of hauls in hours
	100—400	400—1000	1000—2000	>2000	10—25	60—120	200—300	>350		
Northern area.										
Færoes (medio May)	14	..	3	..	6	8	1	2	17	12
S. Iceland to Hebrides (secundo May)	4	6	7	..	7	7	..	3	17	12½
W. of Scotland (primo June)	4	..	18	1	6	7	8	2	23	39
W. of Ireland (medio June)	8	..	..	..	4	4	..	..	8	4
Færoes to E. Iceland (secundo July)	9	3	4	..	5	7	2	2	16	7½
E. Iceland to W. and N. Scotland (secundo August—primo September)	1	3	13	..	4	8	1	1	17	13
Southern area.										
W. and SW. of Ireland (medio June)	2	..	7	..	1	1	4	3	9	30½
S. of Ireland (medio—secundo June)	2	2	11	1	1	2	10	3	16	33

S. Iceland to Hebrides: St. **60.** 61° 50′ N. 11° 38′ W. ²⁸/₅. 1100 m. I: 150 mins. 65 m. w. 2: abt. 9, 21 mm. II: 60 mins. 1000 m. w. 1: 12 mm. St. **61.** 61° 11′ N. 11° 00′ W. ²⁸/₅. 963 m. 30 mins. 65 m. w. 5: 10, 11, 12, 13, 14 mm. St. **63.** 59° 49′ N. 8° 58′ W. ³⁰/₅. 1150 m. I: 30 mins. 65 m. w. 4: 11, 12, 13, 16 mm. II: 60 mins. 1200 m. w. 1: 12 mm. St. **64.** 59° 17′ N. 7° 29′ W. ³⁰/₅. 895 m. I: 30 mins. 25 m. w. 9: 9, 10, 14, 15, 16, 16, 18, 18, 24 mm. II: 60 mins. 65 m. w. 8: abt. 8, 10, 10, 10, 11, 12, 19, 30 mm. III: 60 mins. 1000 m. w. 1: 22 mm. St. **66.** 58° 07′ N. 6° 10′ W. ³¹/₅. 60 m. 30 mins. 65 m. w. 1: 13 mm.

W. of Hebrides: St. **70.** 57° 45′ N. 9° 57′ W. ⁷/₆. 1150 m. 30 mins. 65 m. w. 2: 10, 16 mm. St. **71.** 57° 47′ N. 11° 33′ W. ⁷/₆. 1985 m. 60 mins. 65 m. w. 1: 15 mm. St. **72.** 57° 52′ N. 9° 53′ W. ⁸⁻⁹/₆. 1020—1490 m. I: 120 mins. 65 m. w. 2; 34, 37 mm. (+ 3, length?). II: 120 mins. 100 m. w. 2: 16, 32 mm. III: 300 mins. 200 & 300 m. w. 29: 9, 10, 11, 12, 12, 12, 12, 13, 13, 14, 15, 15, 17, 17, 18, 19, 19, 22, 22, 27, 28, 30, 32, 34, 36, 36, 39, 41, 46 mm.

W. of Scotland: St. **73.** 56° 56′ N. 9° 22′ W. ¹⁰/₆. I: 120 mins. 100 m. w. 1270 m. 2: 23, 28 mm. II: ..... 300 m. w. 1180—1390 m. 2: 13, 26 mm. (+ 3, length?). St. **74.** 56° 00′ N. 9° 32′ W. ¹⁰/₆. I: 120 mins. 200 m. w. 1300 m. 1: 28 mm. II: 120 mins. 300 m. w. 1040 m. 9: 14, 16, 16, 18, 21, 23, 32, 37, 47 mm. St. **75.** 56° 00′ N. 9° 57′ W. ¹¹/₆. 2050 m. 120 mins. 300 m. w. 2: abt. 17, 18 mm. St. **76.** 55° 56′ N. 9° 40′ W. ¹¹/₆. 1390—1405 m. 450 mins. 300 m. w. 4: 13, abt. 14, 16, 26 mm.

W. and SW. of Ireland: St. **81.** 51° 32′ N. 12° 03′ W. ¹³⁻¹⁴/₆. 960—1420 m. 660 mins. 300 m. w. 2: abt. 8, 15 mm. St. **82.** 51° 00′ N. 11° 43′ W. ¹⁴⁻¹⁵/₆. I: 570 mins. 300 m. w. 1020—1370 m. 1: abt. 30 mm. II: 60 mins. 200 m. w. 1400 m. 1: 27 mm. III: 120 mins. 800 m. w. 1400 m. 1: 8 mm. St. **83.** 51° 13′ N. 10° 30′ W. ¹⁵/₆. 146 m. I: 30 mins. 25 m. w. 2: 9, abt. 11 mm. II: 30 mins. 65 m. w. 1: 9 mm. (+ 1, abt. 10 mm.).

S. of Ireland: St. **84.** 51° 24′ N. 8° 18′ W. ¹⁸/₆. 95 m. 30 mins. 65 m. w. 1: 7 mm. St. **92.** 48° 55′ N. 12° 20′ W. ²⁴/₆. 1360—1432 m. 60 mins. 500 m. w. (1: abt. 7 mm.).

English Channel: St. **95.** 49° 56′ N. 5° 00′ W. ²⁷/₆. 74 m. 30 mins. 90 m. w. 1: 9 mm. St. **96.** 50° 15′ N. 4° 19′ W. ²⁷/₆. 50 m. I: 30 mins. 25 m. w. 6: 7, 7, 7, 7, 7, 7 mm. (+ 2, abt. 7 mm.). II: 30 mins. 65 m. w. 2: 7, 7 mm.

Norway to Færoes: St. **118.** 59° 30′ N. 2° 38′ E. ¹⁶/₇. 116 m. 30 mins. 65 m. w. 1: 9 mm. St. **122.** 59° 48′ N. 1° 23′ W. ²³/₇. 85 m. 30 mins. 25 m. w. 1: abt. 7 mm. St. **128.** 60° 15′ N. 2° 38′ W. ²⁸/₇. 157 m. I: 30 mins. 25 m. w. 1: 32 mm. II: 30 mins. 65 m. w. 1: 10 mm. (+ 1, 30 mm?).

E. Iceland to Hebrides: St. **164.** 61° 20′ N. 11° 00′ W. ²⁹/₈. 1300 m. 30 mins. 65 m. w. 1: 27 mm. St. **165.** 60° 00′ N. 10° 35′ W. ²⁹/₈. 1050 m. I: 60 mins. 100 m. w. 2: 26, 27 mm. II: 60 mins. 1000 m. w. (No. of specimens?, length?). St. **166.** 58° 53 N. 10° 15′ W. ³⁰/₈. 1900 m. 60 mins. 100 m. w. 1: 32 mm.

1906.

Locality and Month	Depth in metres				Metres of wire out				Total No.'s of hauls	Total duration of hauls in hours
	100—400	400—1000	1000—2000	>2000	10—25	60—120	200—300	>350		
	Northern area.									
W. of Ireland (secundo June)	..	2	1	2	..	..	3	2	5	8 1/8
W. of Scotland (secundo June)	8	1	2	..	3	3	3	2	11	9 1/8
	Southern area.									
Biscaya (primo—medio May)	11	3	16	..	5	7	12	6	30	47 1/8
S. and SW. of Ireland (secundo May—medio June)	7	3	20	27	2	5	36	14	57	96
S. and SW. of Ireland (secundo Aug.—primo September)	8	3	17	11	2	3	21	13	39	63 1/4
Biscaya (medio September)	7	12	9	..	3	11	8	6	28	41 1/8

English Channel: St. **31.** 49° 45′ N. 4° 42′ W. 7/8. 98 m. 30 mins. 120 m. w. (1: abt. 8 mm.).

Biscaya: St. **41.** 43° 23′ N. 2° 01′ W. 14/8. 102 m. I: 120 mins. 60 m. w. 3: 11, abt. 12, 14 mm. II: 120 mins. 120 m. w. 4: 8, 8, 10, 11 mm. St. **42.** 43° 31′ N. 2° 13′ W. 15/8. 348—420 m. 60 mins. 15 m. w. (2: abt. 10, abt. 10 mm.).

S. to SW. of Ireland: St. **52.** 48° 43′ N. 12° 05′ W. 21/8. 1860— > 1945 m. 120 mins. 300 m. w. 8: abt. 10, 10, 11, 12, 12, 15, 16, 17 mm. (+ 12?, abt. 10—15 mm.). St. **54.** 49° 13′ N. 11° 58′ W. 21/8. 940—975 m. 120 mins. 300 m. w. 1: 13 mm. St. **56.** 51° 24′ N. 10° 20′ W. 22/8. 130 m. 60 mins. 25 m. w. 1: 22 mm. St. **60.** 51° 27′ N. 11° 10′ W. 30/8. 202 m. I: 60 mins. 70 m. w. 1: 35 mm. II: 60 mins. 250 m. w. 1: 18 mm. St. **61.** 51° 04′ N. 11° 39′ W. 31/8. 1020—1450 m. I: 240 mins. 300 m. w. 3: 12, 15, 23 mm. II: 120 mins. 400 m. w. 1: abt. 17 mm. III: 120 mins. 600 m. w. 2: 15, 16 mm. St. **63.** 49° 27′ N. 13° 22′ W. 5/8. 2140 m. 120 mins. 300 m. w. 1: 31 mm. St. **64.** 49° 17′ N. 14° 03′ W. 5/8. > 4000 m. 120 mins. 200 m. w. 1: 10 mm.

SW. of Ireland: St. **70.** 47° 20′ N. 12° 23′ W. 8/8. > 4000 m. 60 mins. 200 m. w. 1: 33 mm. St. **78.** 51° 35′ N. 11° 36′ W. 15/8. 475 m. 120 mins. 300 m. w. (1: abt. 10 mm.).

W. of Ireland: St. **82.** 51° 08′ N. 13° 05′ W. 18/8. > 2000 m. 120 mins. 200 m. w. 1: 10 mm. St. **87.** 54° 30′ N. 11° 19′ W. 22/8. 1740 m. 120 mins. 350 m. w. 1: 23 mm.

1908.

Locality and Month	Depth in metres				Metres of wire out				Total No.'s of hauls	Total duration of hauls in hours
	100—400	400—1000	1000—2000	>2000	10—25	60—120	200—300	>350		
North of Scotland (secundo May)	2	..	..	..	1	1	..	..	2	1/4
Hebrides to Rockall Bank (secundo May)	8	2	1	2	2	11	..	..	13	6 1/8
Rockall Bank to S. Iceland (secundo May—primo June)	..	..	7	..	..	7	..	..	7	3 1/4
E. Iceland to Færoes (primo August)	9	..	..	..	2	5	2	..	9	3

North of Scotland: St. **4.** 59° 42′ N. 4° 30′ W. 21/7. 105 m. 30 mins. 65 m. w. (2: length?). St. **5.** 59° 19′ N. 5° 29′ W. 21/8. 95 m. 30 mins. 65 m. w. 1: 10 mm. (+ 1: length?).

Atlantic between Hebrides and Rockall Bank: St. **11.** 56° 56′ N. 9° 01′ W. 28/8. 140 m. I: 30 mins. 10 m. w. 2: abt. 8, abt. 8 mm. II: 30 mins. 65 m. w. 4: abt. 9, 9, 11, 13 mm. St. **12.** 57° 03′ N. 11° 20′ W. 28/8. > 2400 m. I: 30 mins. 65 m. w. 2: 18, 21 mm. II: 60 mins. 300 m. w. 2: 10, 33 mm. St. **13.** 57° 06′ N. 12° 19′ W. 29/8. > 2250 m. 30 mins. 65 m. w. 2: 16, 18 mm.

Rockall Bank: St. **14.** 57° 09′ N. 13° 16′ W. 29/8. 470 m. 30 mins. 65 m. w. 3: abt. 9, 12, 12 mm. St. **16.** 57° 13′ N. 14° 50′ W. 30/8. 350 m. 30 mins. 65 m. w. 1: 15 mm. St. **17.** 57° 15′ N. 15° 22′ W. 30/8. 1010 m. 30 mins. 65 m. w. 2: 9, 12 mm. St. **18.** 57° 35′ N. 13° 40′ W. 30/8. 105 m. 30 mins. 65 m. w. 3: abt. 8, 8, 13 mm. St. **20.** 57° 59′ N. 13° 06′ W. 31/8. 930—400 m. 30 mins. 65 m. w. 8: abt. 9, 9, 9, 10, 10, 11, 12, 12 mm.

Rockall Bank to S. Iceland: St. **21.** 58° 28′ N. 12° 13′ W. 31/8. 1200 m. 15 mins. 65 m. w. 2: abt. 7, 13 mm. St. **22.** 59° 10′ N. 13° 13′ W. 31/8. > 1655 m. 30 mins. 65 m. w. 2: 11, 13 mm. St. **23.** 59° 43′ N. 14° 07′ W. 1/9. > 1500 m. 30 mins. 65 m. w. 1: abt. 11 mm. St. **24.** 60° 31′ N. 15° 22′ W. 1/9. > 1500 m. 30 mins. 100 m. w. 2: 13, 24 mm.

Færoes to Scotland: St. **98.** 58° 48′ N. 3° 28′ W. 6/8. 90 m. 15 mins. 65 m. w. 1: 10 mm. (+No. of specimens?, abt. 10 mm.).

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REPORT ON THE DANISH OCEANOGRAPHICAL EXPEDITIONS 1908—10
TO THE MEDITERRANEAN AND ADJACENT SEAS

Vol. II. Biology.

D. 3.

Decapoda-Macrura

excl. Sergestidæ.

(*Penæidæ, Pasiphæidæ, Hoplophoridæ, Nematocarcinidæ, Scyllaridæ, Eryonidæ, Nephropsidæ,* Appendix)

by

K. Stephensen.

With 27 figures and 8 charts in the text.

Published August 20, 1921.

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I. INTRODUCTION

The present paper includes those families of Decapoda Macrura (excl. Sergestidæ) which occur, either as adults or larvæ, in the material in so great number of specimens as to be of interest on that account. As might be expected from the method of collecting used by the expedition, they are almost exclusively pelagic species; in some of the families, however, there are also species which live near the bottom; these are here included.

The "Thor"-expedition has moreover, taken a number of species of other families, e. g. Hippolytidæ, Pandalidæ, Palæmonidæ, Crangonidæ; the species in question have, however, here been omitted, as the number of specimens was in every case so small as to afford no fresh information of any interest, not even in respect of localities outside their area of distribution as hitherto known. (The other Decapoda — Brachyura and Anomura + Thalassinidea — are as a rule represented in the material by so few specimens of each, that these likewise could furnish no new information of any importance).

Larvæ which could be ascribed to species dealt with in the present work, or which could at least be with certainty placed as belonging to these families, have been included in their respective sections; all indeterminable larvæ, on the other hand, have been omitted. Possibly these last will be dealt with in Part II of the Decapoda, which will also include the Sergestidæ.

A few species not belonging to the families here in question, but calling for inclusion by reason of some or another feature of interest, are dealt with in an Appendix.

The implement of capture was in practically all cases the young-fish trawl, 200 (more rarely 330) cm diameter.

Save where otherwise mentioned, the animals were always measured from point of rostrum to point of telson; obviously, however, slight inaccuracies can easily occur in these measurements, when endeavouring, for instance, to straighten out a specimen whose tail is more or less bent.

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II. THE FAMILIES AND SPECIES

Penæidea Sp. Bate.

Penæidea Stebbing, S. Africa 1910, p. 379 (lit.).

Fam. Penæidæ Dana.

Penæidæ Bouvier 1908.
— Stebbing, S. Africa 1910, p. 379 (lit.).
— de Man 1911 and 1913.

Of this family, only 12 genera, with 18 species, are known from the area investigated by the "Thor", *Gennadas* alone (including *Amalopenæus*) having seven species, the others only one each.

The Mediterranean has no endemic species. Common to the Atlantic and the Mediterranean are 8 species (see table); the remaining 10 have not at any rate yet been found inside Gibraltar.

The depth of water is great as a rule, over 500 to 1000 m, some few may, however, be found in much shallower water, 20—50 m, (*Solenocera*, *Parapenæus*, *Penæus caramote*), one indeed, (*Sicyonia*) at only 4 m.

The species are (with the few exceptions noted above), abyssal or sub-abyssal bottom forms (for the few pelagic species see below); *Benthesicymus moratus* has even been found at depths from 2500—5450 m.

Of the species from the "Thor"-area, probably only those of the genus *Gennadas* (incl. *Amalopenæus*) and *Funchalia Woodwardii* are pelagic. *Gennadas* was

		Medit.	Atlant.	Depth of the sea (bottom forms)	Pelagic species
	Benthesicymus moratus	..	(×)*	2500—5450 m	..
T[1]	Gennadas elegans	×	×	..	×
	— Alicei	..	(×)	..	×
T	— valens	..	×	..	×
T	— Tinayrei	..	×	..	×
T	— similis n. sp.	..	n*	..	×
T	— chiasmifera n. sp.	..	n	..	×
T	— bidentata n. sp.	..	n	..	×
T	Aristæomorpha foliacea	×	×	500—1300 m	..
	Aristeopsis armatus var. tridens	..	(×)	750—4800 m	..
	Plesiopenæus Edwardsianus	..	(×)	344—1850 m	..
	Aristeus antennatus	(×)	(×)	200—1470 m	..
	Haliporus (Hymenopenæus) debilis	..	(×)	500—1200 (2163) m	.
T	Solenocera siphonocera	×	×	50—200 (760) m	..
T	Funchalia Woodwardii	n	×	..	×
T	Parapenæus longirostris	×	(×)	40—100 (500) m	..
	Penæus caramote	(×)	(×)	20—100 (360) m	..
T	Sicyonia sculpta	×	×	> 4 m	..

[1] T indicates that the species was taken by the "Thor".
(×) - — — - — was not taken by "Thor" in the area in question.
n - — — - — is new to the area in question.

never taken at night much nearer the surface than 200 m. w, and by day only far deeper down (over 1650 m. w. especially), whereas *Funchalia* may be taken during the night very near the surface, and but little deeper during the day.

The great depth sets its mark on their external appearance; all, or nearly all, show different shades of red, with or without blue colouring matter (see especially the colour plates in Bouvier 1908 Pl. 1—3, and notes in Murray and Hjort 1912 p. 669) with exception of the few living at slight depths or near the surface (for these see below). Their abyssal life, on the other hand, does not seem to affect their eyes to any great extent, though these may in some few species be grey or brown (see expecially Murray and Hjort 1912 p. 669); on this point, however, there is very little information to be gleaned from extant works.

Those species which live in comparatively shallow water, or near the surface, bear the stamp of their habitat accordingly; they are transparent, colourless or but faintly coloured with a reddish tinge, or only small red spots (*Solenocera*, *Funchalia*, the young *Parapenæus*), or pale yellow (adult *Parapenæus*) or spotted with brown (*Sicyonia*); only *Penæus caramote* is pale flesh-colour or reddish.

Most of the species are small to medium-sized, abt. 25—100 mm; there is, however, in the "Thor"-area, one veritable giant, to wit, *Plesiopenæus Edwardsianus*, which can attain a length of 315 mm, while *Penæus caramote* can grow to abt. 200 mm.

Gennadas lives in shoals, at any rate at times; the others are rather found singly, with exception of *Penæus caramote*, which is of direct economical importance, being an edible form.

The "Thor"-Expedition. Of the above mentioned 18 species, the "Thor" has 11, three of which are new to science, viz: *Gennadas similis*, *G. chiasmifera* and *G. bidentata*, besides some larvæ (see later on); of these 11 species, however, one, (*Aristæomorpha foliacea*) is not respresented by adult specimens, but only by larvæ.

It is characteristic of the "Thor"-expedition, that it lacks but a single one (*Gennadas Alicei*) of the 8 plankton species found in the area, while only two species of those which live on the bottom (*Solenocera* and *Sicyonia*) are represented by adult specimens, and these two, moreover, live at relatively slight depths; on the other hand, all those species living on the bottom at great depths are entirely lacking in the "Thor" material.

Genus Gennadas Bate (incl. Amalopenæus Smith).

Gennadas Bate 1881, p. 171, 191.
Amalopenæus Smith 1882, p. 86.
**Gennadas* Bouvier 1908, p. 25.
— Kemp 1909, p. 718.
— — , Indian Mus. 1910, p. 173.
Amalopenæus — , Ireland 1910, p. 13.
Gennadas — , — p. 13.
— — 1913, p. 60.
— Stebbing, Edinburgh 1914, p. 282 (lit.).

Kemp (Ireland 1910 p. 13) has shown that *Amalopenæus* should perhaps be distinguished as separate from *Gennadas*, since it lacks podobranchiæ on the pereiopoda. If we maintain *A.* as a distinct genus, it will, apart from *A. elegans* and *A. valens*, hardly contain more than the three new species noted below. I have not here separated the two genera.

Gennadas (+ *Amalopenæus*) includes at present 19 species + three new ones from the "Thor"-expedition (see below), making 22 species in all, besides some uncertain. The most important specific characters lie in the petasma and thelycum, and, as Kemp (1913 p. 60) has pointed out, several of the species are so nearly related that it is very difficult to class a ♂ with its right ♀ and *vice versa*.

We have from the "Thor"-expedition one new ♂ (*G. similis*) and two new ♀ (*G. chiasmifera*, *G. bidentata*). As these also are extraordinarily alike (save, of course in the thelycum and petasma) it is not impossible that one of the two females may belong to the existing male, but as there are distinct, albeit very small differences between ♂ and both the present ♀, I have preferred to place them as three species, leaving it to be shown in course of time, when more material is available, whether this is correct. Of the 19 species previously recorded, both sexes are known in 14 cases, only the ♂ in 4, (*G. intermedius*, *G. Kempi*, *G. præcox*, *G. Talismani*) and only the ♀ in 1 (*G. Bouvieri*). We should be fairly safe in taking it as out of the question that the two new ♀ from the "Thor"-expedition should belong to any of those species of which only the ♂ is hitherto known, and *vice versa*.

A survey of all known species, with their distribution, is given below.

1. *G. Alcocki* ♂♀ Kemp, Indian Mus. 1910, p. 174, Pl. 13 figs. 5—8. Bay of Bengal 765—1644 fms.
— , ♀ — 1913, p. 62, Pl. 7 fig. 8.

Western part of Ind. Oc., 750—0 and 800—0 fms.

2. *G. Alicei* ♂♀ Bouvier 1908, pp. 28, 30 (lit.), Pl. 1 fig. 2 (cold. fig.), Pl. 6. Trop. and subtrop. Atlantic.
— ♀ Milne-Edwards & Bouvier 1909, p. 191. West Indies, 955 fms.
— Lenz & Strunck 1914, p. 309. S. Atlantic.
(*A.*) *Alicei* Sund 1920, p. 29.
3. *G. bidentata* n. sp. ♀, see below.
4. *G. borealis* ♂♀ Rathbun 1902, p. 887 (no fig.). Kamchatka, Bering Sea, 850—1557 fms.
— ♂♀ — 1904, p. 147, figs. 88—89.
5. *G. Bouvieri* ♀ Kemp 1909, p. 726, Pl. 74 figs. 1—4, Pl. 75 figs. 6—7. Manila, N. of New Guinea, 1100—2100 fms.
— ♀ — Indian Mus. 1910, p. 179. Ceylon, 764 fms.
?*G. clavicarpus* de Man 1911, teste de Man.
6. *G. Calmani* ♂♀ Kemp 1909, p. 724, Pl. 74 figs. 5—11, Pl. 75 figs. 4—5. Japan, 345—1875 fms.
7. *Benthesicymus* (?) *carinatus* ♀ Smith 1884, p. 396, Pl. 10 figs. 6—7. 39¾° N, 71° W, 1022 fms.
Gennadas — ♂♀ Kemp, Indian Mus. 1910, p. 179, Pl. 14 figs. 4—9 (lit. and syn.). Arabian Sea, 902—930 fms.
8. *G. chiasmifera* n. sp., ♀, see below.
9. *G. clavicarpus* ♂♀ de Man, Notes from Leyden Mus., vol. 29, 1907, p. 144.
— — 1911, p. 19. Eastern Indian Oc., 0—700 to 0—2000 m.
— — 1913, Pl. 1 fig. 3 a—j, Pl. 2 fig. 3 h—k.
?*G. Bouvieri* Kemp, teste de Man 1911.
10. *G. elegans* ♂♀ Smith, see below.
11. *G. intermedius* (partim) ♂ Bate 1888, p. 343, Pl. 58, fig. 3.
— ♂ Kemp 1909, p. 723, Pl. 73 figs. 7—12, Pl. 75 fig. 3. Sierra Leone 1850 fms., Pernambuco 675 fms.
12. *G. Kempi* ♂ Stebbing, Edinburgh 1914, p. 283, Pl. 27. 39¾° S, 2½° E. 2272 fms.
13. *G. parvus* Bate, Ann. Mag. Nat. Hist. ser. 5, vol. 7, 1881, p. 192 (partim).
— — 1888, p. 340, Pl. 59 (partim).
— ♂ Kemp 1909, p. 721, Pl. 73 figs. 1—6, Pl. 75 fig. 1. Japan 2425 fms.
— ♂♀ — 1913, p. 60, Pl. 7 figs. 6—7. Indian Ocean.
not — Rathbun 1903 (1906), p. 907, p. 60 (teste Kemp, Indian Mus. 1910, p. 175).
14. *G. pasithea* de Man, Notes from Leyden Mus. vol. 29, 1907, p. 146.
— ♂♀ — 1911, p. 16. Banda Sea, 2000—0 m.
— — 1913, Pl. 1 fig. 2 a—j.
15. *G. præcox* ♂ Kemp, Indian Mus. 1910, p. 176, Pl. 13 figs. 1—4. Cape Comorin, 1053 fms.
16. *G. propinquus* ♂♀ Rathbun 1906, p. 907, fig. 61. Hawaiian Isl.
17. *G. scutatus* ♀ Bouvier 1908, p. 28, 42, Pl. 8. Between Açores and New Foundland.
— ♂ Milne-Edwards & Bouvier 1909, p. 193, figs. 10—12. Dominique, 372 fms.
— ♂ Kemp 1909, p. 727, Pl. 75 fig. 2. N. Pacific. 9½° N, 150¾° W. 2700 fms.
— subsp. *indicus* ♂ Kemp, Indian Mus. 1910, p. 178, Pl. 13 figs. 9—10. Cap Comorin, 738—1043 fms.
— ♂♀ Kemp 1913, p. 61. Desroches Atoll, 400—0 fms.
— Lenz & Strunck 1914, p. 310. Cape Verde, Ascension, W. of Capetown.
18. *G. similis* n. sp. ♂, see below.
19. *G. sordidus* ♂ Kemp, Indian Mus. 1910, p. 177, Pl. 14 figs. 1—3. N. of Laccadive Isl., NE. of Ceylon, 764—931 fms.
20. *G. Talismani* ♂ Bouvier 1906, p. 10, 12, fig. 15. Cape Verde.
— — 1908, p. 28.
— ♂ Lenz & Strunck 1914, p. 311, Pl. 18. 17½° N, 29¾° W; ¾° N, 19° W; 8¾° S, 11⅚° W; 35⅔° S, 8¼° E.
21. *G. Tinayrei* ♂♀ Bouvier, see below.
22. *G. valens* ♂♀ Smith, see below.

Doubtful species.

G. sp. ♂ Faxon 1895, p. 207. Equador, 1740 fms.
G. sp. ♀ Rathbun 1906, p. 907, fig. 62. Hawaiian Isl., 1000—1314 fms.
G. sp. ♀ Kemp 1913, p. 62, Pl. 7 fig. 9. Desroches Atoll, 750—0 fms.
G. parvus ♀ Rathbun (not Bate) (teste Kemp, Indian

Mus. 1910, p. 175) 1906, p. 907, fig. 60. Hawaii.

G. (Amalopenæus) valens? ♀ Kemp, Ireland 1910, p. 19, textfig. Ireland.

Distribution of Gennadas T. = taken by the "Thor"-Exped.	Mediteran.	Atlantic			Indian Ocean	Between the great Ind. Isl.	Pacific
		N. of Equat.		S. of Equator			
		E. of 30°W.	W. of 30°W.				
G. Alcocki	..	..	..	..	×	..	..
— Alicei	..	×	×	×	..	..	..
T. — bidentata n. sp.	..	×	..	..	..	..	..
— borealis	..	..	..	..	..	..	×
— Bouvieri	..	..	..	..	×	×	×
— Calmani	..	..	..	..	..	..	×
— carinatus	..	..	×	..	×	..	..
T. — chiasmifera n. sp.	..	×	..	..	..	..	..
— clavicarpus	..	..	..	..	..	×	..
T. — elegans	×	×	×	×	..	..	..
— intermedius	..	×	..	×	..	..	..
— Kempi	..	..	..	×	..	..	..
— parvus	..	..	..	..	×	..	×
— pasithea	..	..	..	..	..	×	..
— præcox	..	..	..	..	×	..	..
— propinquus	..	..	..	..	..	..	×
— scutatus	..	×	..	×	×	..	×
T. — similis n. sp.	..	×	..	..	..	..	..
— sordidus	..	..	..	..	×	..	..
— Talismani	..	×	..	×	..	..	..
T. — Tinayrei	..	×	×	×	..	..	..
T. — valens	..	×	×	×	..	..	..
No. of species	1	10	5	8	7	3	6

1. GENNADAS ELEGANS Smith.

Gennadas elegans Lo Bianco 1904, p. 29—31, Pl. 9 fig. 37 (cold. fig.).

— — Bouvier 1908, p. 28, 35 (lit. and syn.), Pl. 7.

Amalopenæus— Kemp, Ireland 1910, p. 14, Pl. 1.

Gennadas — Murray & Hjort 1912, p. 668.

Amalopenæus— Pesta 1918, p. 33, figs. 1—2.

— — Sund 1920, p. 27.

Mediterranean.

St. 13. > 1200 m. 39°43′ N, 17°30′ E. 19-12-1908. 65 m.w., 8^{50} pm., 60 min. 4 ♀ 16 mm. — **St. 13.** ibid. 300 m.w., 5^{35} pm., 60 min. 40 spec.: 13 ♂: 12 ♂ 19—21 mm., 1 ♂ 24 mm.; 27 ♀: 22 spec. 17—22 mm., 5 spec. 23—27 mm. — **St. 13.** ibid. 1000 m.w., 7^{05} pm., 60 min. 35 spec.: 1 spec. 14 mm.; 13 ♂: 9 spec. 20—22 mm., 4 spec. 23—25 mm.; 20 ♀ 20—25 mm, 1 ♀ 17 mm. — **St. 14.** 1125 m. 41°24′ N, 17°45′ E. 21-12-1908. 300 m.w., 6^{30} am., 60 min. 1 ♂ 24 mm., 1 ♀ 24 mm. — **St. 15.** 1000 m. 40°04′ N, 19°06′ E. 22-12-1908. 1400 m.w., hour ?, 60 min. 3 ♂ 24 mm. — **St. 24.** > 3700 m. 40°14′ N, 12°23′ E. 16-1-1909. 1600 m.w., 240 min., 11^{15} pm. 1 ♀ 25 mm. — **St. 24.** ibid. 300 m.w., 30 min., hour ?, 35 spec.: 10 ♂ 20—22 mm., 25 ♀ 17—26 mm. — **St. 29.** 1550 m. 40°47′ N, 12°55′ E. 20-1-1909. 600 m.w., 9^{30} pm., 60 min. 11 spec.: 6 ♂ 20 mm., 5 ♀: 17 (3 spec.), 21, 27 mm. — **St. 29.** ibid. 1650 m.w., 2^{15} pm., 60 min. 10 spec.: 3 ♂ 20—22 mm., 7 ♀ 16—23 mm. — **St. 31.** 1420 m. 41°44′ N, 10°52′ E. 22-1-1909. 200 m.w., 3^{15} am., 30 min. 60 spec.: 3 ♂ 18—21 mm., 57 ♀: 1 ♀ 15 mm., 56 ♀ 18—25 mm. — **St. 31.** ibid. 600 m.w., 3^{05} am., 30 min. 19 spec.: 4 ♂ 16, 16, 18, 22 mm.; 15 ♀ 16—24 mm. — **St. 31.** ibid. 1400 m.w., 1^{20} am., 60 min. 23 spec.: 5 ♂ 16—22 mm.; 18 ♀: 4 ♀ 16 mm., 14 ♀ 18—24 mm. — **St. 35.** > 2000 m. 43°36′ N, 7°36′ E. 29-1-1909. 1000 m.w., 11^{25} am., 120 min. 3 ♂ 20, 20, 23 mm. — **St. 35.** ibid. 1600 m.w., 11^{25} am., 120 min. 34 spec.: 13 ♂ 22—26 mm.; 21 ♀: 1 ♀ 20 mm., 20 ♀ 22—29 mm. — **St. 35.** ibid. 2500 m.w., 3^{45} pm., 90 min. 22 spec.: 10 ♂ 22—24 mm., 12 ♀: 3 ♀ 17—21 mm., 9 ♀ 22—28 mm. — **St. 45.** 2150 m. 37°28′ N, 8°18′ E. 6-2-1909. 300 m.w., 11^{25} pm., 30 min. 12 spec.: 3 ♂ 16—18 mm.; 9 ♀ 15—19 mm. — **St. 46.** 1930 m. 37°17′ N, 6°00′ E. 7-2-1909. 65 m.w., 30 min., 8^{20} pm. 30 spec.: 16 spec. (9)11—13 mm., 6 spec. 14—16 mm.; 3 ♂ 18—19 mm.; 5 ♀ 17—19 mm. — **St. 46.** ibid. 300 m.w., 7^{30} pm., 30 min. 84 spec.: 29 spec. (9)12—14 mm.; 30 ♂ 18—20 mm.; 25 ♀: 22 ♀ without ova: 1 ♀ 21 mm., 21 ♀ 15—20 mm.; 3 ♀ with ova in ovarium 20—23 mm. — **St. 46.** ibid. 600 m.w., 6^{35} pm., 30 min. 30 spec.: 8 spec. 8—12 mm., 2 spec. 14—16 mm., 11 ♂ 17—20 mm., 9 ♀ 17—22 mm. — **St. 47.** > 2000 m. 36°55′ N, 3°12′ E. 10-2-1909. 300 m.w., 11^{05} pm., 30 min. 9 spec.: 3 spec. 11—16 mm., 2 ♂ 18—19 mm., 4 ♀ 17—21 mm. — **St. 50.** > 2000 m. 37°02′ N, 1°17′ E. 12-2-1909. 600 m.w., 4^{10} am., 30 min. 60 spec.: 5 spec. 11—14 mm., 16 ♂ 17—20 mm., 39 ♀ 17—25 mm. (incl. 3 ♀ with ova in the ovarium 18—20 mm.). — **St. 50.** ibid. 1600 m.w., 5^{30} am., 60 min. 20 spec.: 4 spec. 7.5—15 mm.; 7 ♂ 19—22 mm.; 9 ♀ 18—23 mm. — **St. 51.** > 2000 m. 36°27′ N, 6°27′ E. 18-2-1909. 300 m.w., 0^{50} am., 30 min. 68 spec.: 2 spec. 11—13.5 mm.; 29 ♂ 17—21 mm.; 37 ♀ 16—22 mm. — **St. 53.** > 2000 m. 36°13′ N, 1°28′ W. 18-2-1909. 2600 m.w., 5^{15} pm., 90 min. 52 spec.: 1 spec. 9 mm., 8 spec. 12—15 mm., 20 ♂ 16—21 mm., 23 ♀ 16—20 mm. — **St. 59.** 1260 m. 36°02′ N, 4°24′ W. 21-2-1909. 100 m.w., 1^{00} am., 30 min. 1 ♀ 19 mm. — **St. 59.** ibid. 500 m.w., 1^{40} am., 30 min. 22 spec.: 6 spec. 12—15 mm., 2 ♂ 20 mm.; 14 ♀ 16—24 mm. (incl. 2 with ova in the ovarium 20—22 mm.). — **St. 59.** ibid. 1200 m.w., 2^{30} am., 30 min. 41 spec.: 6 spec. 9 mm., 1 spec. 13 mm., 16 ♂ 16—22 mm., 18 ♀ (incl. 1 ♀ with ova in ovarium 24 mm.) 16—25 mm. — **St. 61.** 740 m. 35°57′ N, 5°35′ W. 21-2-1909. 600 m.w., 3^{25} pm., 60 min. 1 spec. 9 mm., 1 ♂ 20 mm. — **St. 106.** 1150 m. 36°33′ N, 2°00′ W. 25-6-1910. 1200 m.w., 0^{20} am., 60 min. 102 spec.: 8 spec. 7—10 mm., 55 spec. 11—15 mm., 12 ♂ 17—18 mm., 27 ♀ 16—25 mm. (incl. 4 ♀ with ova in the ovarium 19—20 mm.). — **St. 107.** > 2000 m. 36°13′ N, 1°28′ W. 25-6-1910. 2000 m.w., 7^{30} am., 60 min. 152 spec.: 24 spec. 7—10 mm., 45 spec. 11—15 mm., 24 ♂ 16—20 mm., 59 ♀ 16—23 mm. (incl. 1 ♀ with ova in ovarium 20 mm.). — **St. 108.** 2435 m. 36°03′ N, 0°27′ W. 26-6-1910. 2000 m.w., 0^{40} am., 60 min. 167 spec.: 34 spec. 8—11 mm.; 65 spec. 12—15 mm.; 23 ♂ 16—20 mm.; 45 ♀ 16—21 mm. (incl. 1 ♀ with ova in ovarium 21 mm.). — **St. 112.** 2700 m. 36°56′ N, 2°15′ E. 27-6-1910. 300 m.w., 0^{15} am., 30 min. 66 spec.: 47 spec. 11—15 mm., 3 spec. 8—10 mm., 5 ♂ 17—20 mm., 11 ♀ 17—18 mm. — **St. 113.** 815 m. 36°53′ N, 3°09′ E. 28-6-1910. 300 m.w.,

3^{25} am., 30 min. 2 ♀ 19—22 mm. — **St. 115.** 2800 m. 38°17′ N, 4°11′ E. 28-6-1910. 300 m.w., 11^{20} pm., 30 min. abt. 275 spec.: abt. 50 spec. 11—15 mm., abt. 75 ♂ 16—20 mm., abt. 150 ♀ 16—25 mm. — **St. 115.** ibid. 2000 m.w., 0^{30} am., 60 min. 110 spec.: abt. 20 spec. (8) 12—15 mm.; abt. 20 ♂ 16—23 mm.; abt. 70 ♀: abt. 67 ♀ 16—24 mm., 3 ♀ 25—27 mm. — **St. 116.** 2860 m. 39°27′ N, 5°26′ E. 30-6-1910. 300 m.w., 1^{40} am., 30 min. 11 spec.: 6 spec. 10—15 mm.; 5 ♀ 16—19 mm. — **St. 118.** > 2700 m. 41°00′ N, 6°43′ E. 30-6-1910. 65 m.w., 11^{35} pm., 30 min. 1 spec. 15 mm. — **St. 118.** ibid. 300 m.w., 10^{55} pm., 30 min. 86 spec.: 11 spec. 7—10 mm., abt. 20 spec. 11—15 mm.; abt. 15 ♂ 16—20 mm.; abt. 40 ♀ 16—22 mm. — **St. 120.** 2700 m. 42°31′ N, 7°41′ E. 1-7-1910. 300 m.w., 8^{50} pm., 30 min. 25 spec.: 4 spec. 15 mm.; 5 ♂ 18—22 mm.; 16 ♀: 12 ♀ 16—19 mm., 4 ♀ 24—26 mm. — **St. 122.** 1500 m. 43°50′ N, 8°34′ E. 2-7-1910. 1200 m.w., 5^{30} pm., 60 min. 5 spec.: 2 ♂ 20 mm., 2 ♀ 21—27 mm.; 1 spec. 14 mm. — **St. 129.** 3420 m. 40°05′ N, 11°31′ E. 12-7-1910. 600 m.w., 8^{00} pm., 30 min. 13 spec.: 8 spec. 15 mm., 2 ♂ 17—20 mm., 3 ♀ 16—17 mm. — **St. 129.** ibid. 1000 m.w., 4^{20} am., 60 min. 22 spec.: 2 spec. 9—11 mm., 12 spec. 12—15 mm., 1 ♂ 20 mm., 7 ♀ 16 mm. — **St. 129.** ibid. 3500 m.w., 3^{00} pm., 120 min. 31 spec.: 15 spec. 11—15 mm.; 6 ♂ abt. 20 mm., 10 ♀: 1 ♀ 25 mm., 9 ♀ 19—20 mm. — **St. 143.** 1842 m. 35°18′ N, 16°25′ E. 23-7-1910. 300 m.w., 0^{30} am., 30 min. 2 spec. 13 mm. — **St. 143.** ibid. 1000 m.w., 2^{00} am., 60 min. 2 spec.: 1 spec. 14 mm., 1 ♂ 22 mm. — **St. 144.** 3340 m. 34°31′ N, 18°40′ E. 24-7-1910. 2000 m.w., 3^{45} am., 60 min. 1 ♀ 19 mm. — **St. 144.** ibid. 4000 m.w., 6^{20} am., 60 min. 3 spec.: 1 ♂ 18 mm., 2 ♀ 20—22 mm. — **St. 147.** 960 m. 31°35′ N, 15°02′ E. 26-7-1910. 1000 m.w., 1^{10} am., 60 min. 3 spec.: 1 spec. 14 mm., 1 ♂ 19 mm., 1 ♀ 19 mm. — **St. 156.** > 3000 m. 32°31′ N, 26°51′ E. 30-7-1910. 600 m.w., 3^{00} am., 30 min. 1 ♂ 19 mm. — **St. 156.** ibid. 1000 m.w., 0^{40} am., 60 min. 2 spec.: 1 ♂ 19 mm., 1 ♀ 22 mm. — **St. 160.** >1000 m. 35°59′ N, 28°14′ E. 1-8-1910. 300 m.w., 2^{45} am., 30 min. 2 spec. 13—14 mm. — **St. 160.** ibid. 1000 m.w., 3^{15} am., 60 min. 32 spec.: 3 spec. 9—12 mm., 26 spec. 13—15 mm., 1 ♂ 20 mm., 2 ♀ 21—22 mm. — **St. 160.** ibid. 4000 m.w., 3^{30} pm., 60 min. 17 spec.: 12 spec. 9—15 mm., 2 ♂ 19 mm., 3 ♀ 21—24 mm. — **St. 163.** 1180 m. 37°52′ N, 26°22′ E. 3-8-1910. 300 m.w., 1^{05} am., 15 min. 1 spec. 15 mm. — **St. 163.** ibid. 1000 m.w., 0^{05} am., 30 min. 2 spec. 12—13 mm. — **St. 175.** 1103 m. 40°48′ N, 27°59′ E. 11-8-1910. 400 m.w., 11^{20} pm., 30 min. 16 spec.: 1 spec. 8 mm., 8 ♂ 22—23 mm., 7 ♀ 22—27 mm. — **St. 175.** ibid. 1200 m.w., 0^{25} am., 30 min. 19 spec.: 4 ♂: 3 ♂ abt. 22 mm., 1 ♂ 27 mm.; 15 ♀: 11 ♀ 21—23 mm., 4 ♀ 27—28 mm. — **St. 184.** 842 m. 38°10′ N, 22°33′ E. 17-8-1910. 1000 m.w., 2^{45} am., 30 min. 1 ♂ 23 mm., 1 ♀ 23 mm. — **St. 187.** > 2500 m. 37°54′ N, 18°02′ E. 18-8-1910. 1000 m.w., 6^{40} pm., 30 min. 1 ♂ 21 mm., 1 ♀ 21 mm. — **St. 199.** 2700 m. 39°32′ N, 10°49′ E. 28-8-1910. 300 m.w., 9^{25} pm., 20 min. 6 spec. 12—15 mm. — **St. 199.** ibid. 1000 m.w., 10^{10} pm., 30 min. 10 spec.: 8 spec. 10—15 mm., 2 ♀ 16—20 mm. — **St. 206.** 2782 m. 39°32′ N, 5°15′ E. 28-8-1910. 300 m.w., 1^{05} am., 15 min. 1 spec. 15 mm. — **St. 206.** ibid. 1000 m.w., 1^{40} am., 45 min. 35 spec.: 18 spec. 14—15 mm., 6 ♂ 16—19 mm.; 11 ♀: 8 ♀ 16—20 mm., 3 ♀ 21—25 mm. — **St. 206.** ibid. 2000 m.w., 3^{05} am., 45 min. 65 spec.: abt. 10 spec. 12—15 mm., abt. 15 ♂ 16—25 mm., abt. 40 ♀ 16—26 mm. — **St. 209.** 2131 m. 40°34′ N, 3°03′ E. 29-8-1910. 1000 m.w., 6^{00} am., 45 min. 12 spec.: 4 spec. 8—9 mm., 8 spec. 13—14 mm. — **St. 209.** ibid. 2000 m.w., 7^{25} am., 45 min. 112 spec.: abt. 12 spec. 13—15 mm.; abt. 30 ♂: 1 ♂ 25 mm., abt. 29 ♂ 16—20 mm.; abt. 70 ♀: abt. 69 ♀ 16—23 mm., 1 ♀ 29 mm. — **St. 209.** ibid., dredge, 2800 m.w., 9^{30} am., 180 min. 1 ♀ 17 mm. — **St. 218.** 2147 m. 36°54′ N, 2°57′ E. 2-9-1910. 300 m.w., 2^{45} am., 30 min. 58 spec.: 9 spec. 8—11 mm., 14 spec. 12—15 mm., 6 ♂ 16—21 mm., 29 ♀ 16—25 mm. — **St. 222.** 1950 m. 35°53′ N, 0°57′ W. 4-9-1910. 300 m.w., 11^{20} pm., 30 min. 25 spec.: 1 spec. 6 mm.; 6 ♂ abt. 18 mm.; 18 ♀ 16—23 mm. — **St. 228.** 874 m. 36°02′ N, 5°06′ W. 7-9-1910. 1200 m.w., 0^{50} am., 30 min. 31 spec.: 3 spec. 12, 15, 15 mm.; 13 ♂ 17—21 mm.; 15 ♀ 19—22 mm.

Atlantic.

St. 164. 1900—2150 m. 62°10.8′ N, 19°36′ W. 12(13)-7-1903. 1 ♂ 23 mm., 1 ♀ 25 mm. — **St. 104.** 1950 m. 62°47′ N, 15°03′ W. 24-5-1904. 1800 m.w. 1 ♂ 22 mm. — **St. 152.** 1240 m. 65°00′ N, 28°10′ W. 19-6-1904. 1000 m.w., 12 spec.: 2 ♂ 21 mm., 10 ♀: 9 spec. 21—22 mm., 1 spec. 29 mm. — **St. 180.** 2160 m. 61°34′ N, 19°05′ W. 10-7-1904. 1800 m.w. 9 spec.: 4 ♂ 21, 23, 24, 27 mm.; 5 ♀ 23, 24, 25, 25, 29 mm. — **St. 183.** > 2000 m. 61°30′ N, 17°08′ W. 11-7-1904. 1800 m.w. 33 spec.: 13 ♂: 12 spec. 23—25 mm., 1 spec. 30 mm.; 20 ♀: 17 spec. 21—27 mm., 3 spec. 31—36 mm. — **St. 63.** 1150 m. 59°49′ N, 8°58′ W. 30-5-1905. 1200 m.w. 5 spec.: 3 ♂ 22—23 mm., 2 ♀ 22 mm. — **St. 71.** 1985 m. 57°47′ N, 11°33′ W. 7-6-1905. 1500 m.w. 8 spec.: 5 ♂ abt. 23 mm., 3 ♀ 23—27 mm. — **St. 72.** 1020 m. 57°52′ N, 9°53′ W. 8-6-1905. 1500 m.w. Abt. 30 spec.: 10 spec. abt. 25 mm.: 5 ♂, 5 ♀; abt. 20 spec. 7—8 mm. — **St. 165.** 1050 m. 60°00′ N, 10°35′ W. 29-8-1905. 1000 m.w. 19 spec. 12—15 mm. — **St. 167.** 1260 m. 57°46′ N, 9°55′ W. 1-9-1905. 1500 m.w. 14 spec. 12—15 mm. — **St. 88.** 600—995 m. 48°09′ N, 8°30′ W. 20-6-1905. 300 m.w., 11^{45} pm., 240 min. 1 spec. 10 mm. — **St. 62.** 2480—2775 m. 50°25′ N, 12°44′ W. 5-6-1906. 1500 m.w., 2^{45} am., 120 min. 11 spec.: 5 ♂ abt. 22 mm., 6 ♀: 5 spec. 22—23 mm., 1 spec. 29 mm. — **St. 74.** 1245—1298 m. 49°23′ N, 12°13′ W. 10-6-1906. 2000 m.w., 6^{35} am., 60 min. 11 spec.: 7 ♂ 24—27 mm., 4 ♀ 22, 23, 23, 33 mm. — **St. 74.** ibid. 2000 m.w. (Eeldrift-seine), 1^{20} pm., 60 min. 1 ♀ 27 mm. — **St. 76.** > 2800 m. 49°27′ N, 13°33′ W. 11-6-1906. 2800 m.w., 3^{00} pm., 120 min. 4 spec.: 2 ♂ 26—29 mm., 2 ♀ 25—32 mm. — **St. 178.** 4000 m. 48°04′ N, 12°40′ W. 2-9-1906. 1800 m.w., 9^{05} am., 120 min. 7 spec.: 4 ♂: 25, 25, 27, 29 mm.; 3 ♀ 29, 29, 35 mm. — **St. 179.** 4000 m. 47°20′ N, 12°23′ W. 3-9-1906. 600 m.w., 0^{00} am., 120 min. 2 ♂ 26—30 mm. — **St. 180.** 4000 m. 48°19′ N, 13°53′ W. 3-9-1906. 1800 m.w., 60 min. 5^{05} pm., 6 spec.: 2 ♂ 24—27 mm.; 4 ♀: 2 ♀ 15—17 mm., 2 ♀ abt. 32 mm. — **St. 181.** 1350 m. 49°22′ N, 12°52′ W. 4-9-1906. 1800 m.w., 10^{35} am., 60 min. 4 ♀: 1 ♀ 19 mm., 3 ♀ abt. 33 mm. — **St. 190.** 4000 m. 46°30′ N, 7°00′ W. 11-9-1906. 2700 m.w., 8^{25} am., 150 min. 1 ♂ 29 mm., 1 ♀ 33 mm. — **St. 65.** 1300 m. 35°53′ N, 7°28′ W. 24-2-1909. 1600 m.w., 0^{30} pm., 120 min. 5 spec.: 1 ♂ 19 mm., 4 ♀ 17, 21, 26, 29 mm. — **St. 66.** 735 m. 36°16′ N, 6°52′ W. 25-2-1909. 300 m.w., 2^{55} am., 120 min. 2 ♀ 17—19 mm. — **St. 69.** > 3500 m. 36°13′ N, 9°48′ W. 28-2-1909. 600 m.w., 9^{00} pm., 60 min. 1 ♂ 19 mm. — **St. 69.** ibid. 3000 m.w., 6^{30} pm., 60 min. 4 spec.: 2 ♂ 19—21 mm., 2 ♀ abt. 25—30 mm. — **St. 71.** 1150 m. 39°35′ N, 9°43′ W.

4-3-1909. 1600 m.w., 4^{00} pm., 120 min. 14 spec.: 4 ♂ 21—23 mm., 10 ♀ 18—24 mm. — **St. 74.** 2000 m. 44°21′ N, 7°55′ W. 9-3-1909. 600 m.w., 0^{10} am., 60 min. 1 ♀ 33 mm.

The material contains totally 2473 spec. (580 ♂, 1164 ♀, 729 spec. 9—15 mm) from 65 stations, 96 hauls.

A. Mediterranean.

	Stations	Hauls	No. of specimens ♂	♀	Jun. 9-15mm.	total
Dec. 1908.....	3	5	30	53	1	84
Jan. 1909.....	4	10	57	161	—	218
Feb. —	8	13	140	193	98	431
June 1910.....	8	10	174	409	389	972
July —	7	12	21	43	46	110
Aug. —	8	17	68	153	114	335
Sept. —	3	3	25	62	27	114
total...	41	70	515	1074	675	2264

Depths of the sea and occurrence. Of the 41 stations where the species was taken, 12 lie in the eastern basin, the species having been taken as far in as the Adriatic and the Marmora. The remaining 29 stations lie more or less evenly distributed throughout the western basin.

The depth of sea is over abt. 850 m, especially 1000—3000 m.

Depths in m.	No. of stations
> 500—1000 ...	6
> 1000—2000 ...	13
> 2000—3000 ...	18
> 3000 ...	4
total...	41

Two hauls (from st. 15, 1908, and st. 24, 1909) having given total 38 spec., are omitted here, the hour being not noted (day?, night?)			No. of hauls	Duration in hours	No. of spec.	No. of spec. pr. hour
Eastern Basin	Winter	Night..	2	2	36	18
		Day...	2	2	42	21
	Summer	Night..	13	8.75	44	5
		Day...	2	2	20	10
		total...	19	14.75	142	9.6
Western Basin	Winter	Night..	16	13	494	38
		Day...	6	9	123	13.7
	Summer	Night..	22	13.25	1166	88
		Day...	5	7.75	301	38.8
		total...	49	43	2084	48.5

Taking as negative all stations where depth is over 500 m, and night hauls made with over 50 m.w. showed no specimens taken, we have in the eastern basin 3 negative stations (with an additional one in the Black Sea) as against 12 positive. The western basin has 20 negative stations scattered evenly about among the 29 positive. Thus, though we have relatively more positive stations in the eastern basin than in the western, the hauls made in the western basin gave a comparatively far larger yield, viz:

Western basin (49 hauls, 43 hours, 2084 spec.), or 42.5 spec. per haul, 48.5 per hour, while the eastern basin (19 hauls, 14.75 hours, 142 spec.) only yielded 7.5 specimens per haul, or 9.6 per hour.

The table further shows that the eastern basin in winter gave more specimens per hour than in summer, while the reverse is the case in the western basin.

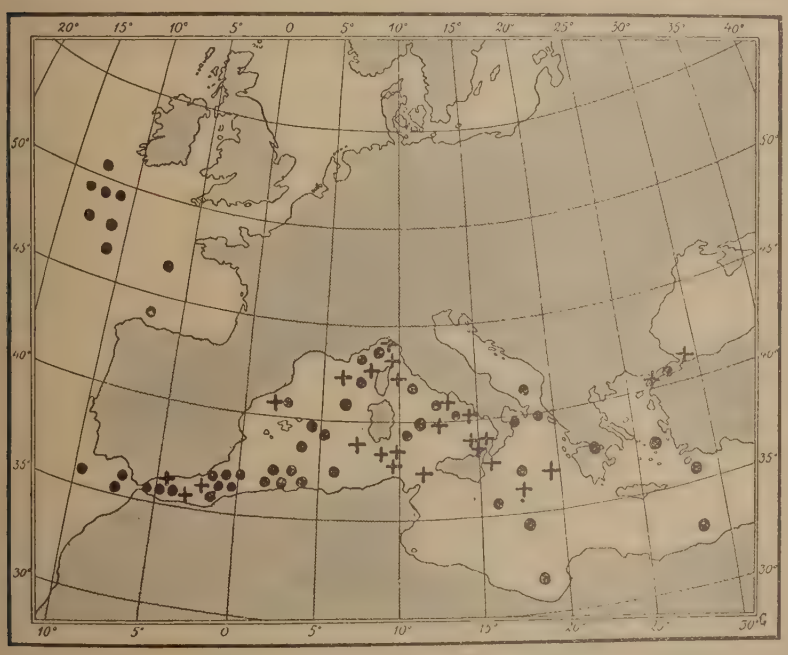

Chart 1. Gennadas elegans. ● positive stations (the stations from 1903—04 lie outside the chart to N.W.). + negative stations (> 500 m, night, > 50 m.w.) (not noted in the Atlantic).

Vertical occurrence.

Winter.

Night, m.w.	Hauls	Specimens	Durations of hauls in hours	No. of spec. pr. hour
65— 100	3	35	2	17.5
200	1	60	0.5	120
300	4	173	2	86.5
500— 600	5	142	3	47.3
1000—1200	2	76	1.5	50.7
1600	3	44	6	7.3
total...	18	530	15	35.3
Day				
[300	2	42	2	21.0][1]
600	1	2	1	2
1000	1	3	2	1.5
1650	2	44	3	14.7
2500—2600	2	74	3	24.7
total...	8	165	11	15

[1] see the text.

Night, m.w.	Spec. total		Spec. 9—15 mm.	% of spec. 9—15 mm.	
65	35		22	62.9	
200	60	233	—	0	17.2
300— 400	173		40	23.9	
500— 600	142		21	14.7	
1000—1200	76		8	10.5	
1600	44		4	9.1	

Summer.

Night, m.w.	Hauls	Specimens	Durations of hauls in hours	No. of spec. pr. hour
65	1	1	0.5	2
300— 400	14	576	6.25	92.1
600	2	14	1	14
1000—1200	14	276	10.5	26.3
2000	4	343	3.75	91.5
total...	35	1210	22.0	55
Day				
1200	1	5	1	5
2000—2800	3	265	4.75	55.8
3500—4000	3	51	4	12.8
total...	7	321	9.75	32.9

Winter. 2 winter hauls (300 and 1400 m.w., total 38 spec.) cannot be included, as the time was not noted.

The 18 night hauls have a line-length of 65—1600 m.w. but the no. of specimens per hour shows that the species was taken almost exclusively with 200—1200 m.w. especially 200 m.w. In the daytime, it was taken with 300—2600 m.w., especially 1650—2600 m.w. The great number of specimens at 300 m.w. is due to a single haul (St. 13, $^{19}/_{12}$ 1908, 5.35 p. m.) which yielded 40 specimens; owing to the season, however, this should certainly be regarded as a night haul, though actually made in the afternoon (5.35 p. m.).

As regards size of the specimens, it will be seen that large and small are found evenly together; the small ones (9—15 mm) keep more particularly to the upper water layers, 65 m.w. (never taken nearer the surface than this) comparatively few being taken at the greater depth, the reverse being the case with the larger individuals.

Summer. At night, the species was taken with 65—2000 m.w but practically speaking, only with at least 300 m.w. Strangely enough, almost equal numbers per hour were taken with 300—400 m.w. and with 2000 m.w., the intermediate water layers giving far smaller numbers.

In the daytime, it was only taken with 1200—4000 m.w., especially 2000—2800 m.w. The small specimens (9—15 mm) are in summer, strangely enough, more evenly distributed among the large in regard to depth than in winter.

These results agree very well with Murray & Hjort 1912 p. 668; they have 292 specimens, of which 220 were taken by day at a depth of 500 to over 1500 m, especially at 750—1000 metres down; at night, 72 specimens, 150—over 1500 m down, especially at 150—1250 m. See also Bouvier 1908 p. 26. —

The colour is red with blue spots; see especially Kemp, Ireland 1910, p. 15—16; a coloured figure is given by Lo Bianco, 1904 fig. 37. Eyes brown (Murray & Hjort 1912, p. 669).

Size and propagation. The size is generally up to 24 mm, specimens of either sex can however grow to 27 mm the ♀ even to 29 mm. (Kemp 38 mm, Pesta 1918 30—40 mm, Smith 43 mm) but only a few specimens as large as this have been found. The petasma can be distinguished when the ♂ is 16 mm (Bouvier gives 14 mm); in specimens of 18 mm the petasma can be fully developed (Bouvier has 25 mm, but most of his material is from the Atlantic). Pesta, 1918, notes, strangely enough, that specimens less than 30—40 mm are not mature.

As the female lays her eggs directly into the water, not carrying them about with her for a time, it is impossible to determine the time when eggs are laid by observation of egg-bearing females. It has been found, however, that a number of them have ova in the ovary,

visible through the thin skin, and were it not that part of the material is somewhat damaged as to the hinder portion of the pereion, body and tail breaking a little apart, we might certainly have found far more. Females with ova in the ovarium are (18) 20—24 mm. They were taken on the 7.—21. Feb. night, 300—1200 m.w., and 25. June, night, 1200—2000 m.w. The species thus propagates all the year round. The smallest specimens are (6) 9—10 mm.

For probable larvæ of the species see below, under *Euphema* (*armata* M.-Edw.?) p. 21.

B. Atlantic.

The material contains 209 spec. (65 ♂, 90 ♀, 54 spec. 8—15 mm.) from 24 st., 26 hauls.

The stations range from south of Iceland (1903—04) round the Irish coast (1905—06) to the Bay of Cadiz (1909).

It appears to agree in every respect with the Mediterranean, save in the fact that it does not come up quite so near the surface either day or night; and also, in attaining a somewhat larger size: ♂ 30 mm., ♀ 33 mm.

Summary.

The species keeps almost exclusively to depths of sea beyond 1000 m., especially 1000—3000 m. The "Thor" has taken it from south of Ireland to the eastern part of the Mediterranean. It is pelagic; at night it was taken especially with 200—300 m.w., by day especially 1650—2800 m.w., and there does not appear to be any perceptible difference (in the Mediterranean) in regard to season. The smaller specimens are most numerous near the upper limit of the species, the larger ones lower down. The species occurs often, at any rate, in shoals.

It is found in the Mediterranean in both basins, being, however, more numerous in the western, which agrees with the fact of its penetrating, in the Atlantic, far to the northward, as far as Iceland and Greenland. It is the only Penæid which has been met with in such high latitudes. In the Mediterranean, it probably breeds all the year round.

Distribution.

Mediterranean; Atlantic from Greenland to S. Africa.

1. Mediterranean. On the "Thor" see above. — Capri, several st.; between Capo Corso and Villafranca; Salina (Eolian Isl.) (Lo Bianco 1902, 1903, 1904). — 12 st. abt. from Valencia to Capri (Bouvier 1908). — Messina (Riggio 1901). — Southern Adria (Szütz 1915, Pesta 1918).

2. Atlantic. On the "Thor" see above. — W. Greenland 60°—65½° N, 839—2000 m. w., several st. (K. Stephensen 1913). — E. Greenland 64½° N, 31°—32½° W, 1300—2000 m.; W, SW, S. and E. of Iceland, 582—1300 fms. (H. J. Hansen 1908). — E. America 31¾°—41¼° N, 372—2369 fms. (Smith 1882). — W and SW Ireland, several st. (Calman 1903; Kemp, Ireland 1910). — Biscaya (Kemp 1907, p. 206; Bouvier 1908, st. 1549, 1583). — Cadiz Bay (Bouvier 1908, st. 1905, 2016). — Between Europe and New Foundland (Murray and Hjort 1912, p. 669; Sund 1920, p. 27). — Several stations abt. 30°—40° N, 22°—42° W; Madeira 3 st.; 16°55′ N, 25°21¾′ W (Bouvier 1908). — Abt. 31° N, 40° W, closing net 1300—1500 m.; 12.3° N, 22.3° W, 0—400 m. (Ortmann 1893). — St. Lucia (W. Indies), 423 fms. (Milne-Edwards and Bouvier 1909). — 0°46′ N, 18°59′ W; 8°43′ S, 11°55′ W; 35°39′ S, 8°16′ E (Lenz & Strunck 1914). — Cape Point Lighthouse S. 83° E, 35½ miles, 360 fms. (Stebbing 1918 [1919?]).

2. GENNADAS TINAYREI Bouvier.

Gennadas Tinayrei Bouvier 1908, p. 29, 48 (lit.), Pl. 1 fig. 4 (cold. fig.), Pl. 10.
— — Murray & Hjort 1912, p. 668.
Amalopenæus — Sund 1920, p. 29.

Atlantic.

St. 65. 1300 m. 35°53′ N, 7°21′ W. 24-2-1909. 1600 m.w., 0^{30} pm., 120 min. 28 spec.: 13 ♂ 17—23 mm., 15 ♀ 16—22 mm. — **St. 69.** > 3500 m. 36°13′ N, 9°44′ W. 28-2-1909. 300 m.w., 11^{40} pm., 30 min. 33 ♀ 18—20 mm. — **St. 69.** ibid. 600 m.w., 9^{00} pm., 60 min. 4 ♂ 22—24 mm.

Colour: red (the adult; Bouvier p. 50, Pl. 1 fig. 4) or red orange (the young; Bouvier p. 50). Murray & Hjort give the colour as »coralline, bright-blue patches; eyes darkbrown, ratio of carapace to eyes 7.7.« —

The "Thor" took 65 specimens in all, (17 ♂, 48 ♀); previously, only about 50 specimens were known, (Bouvier 6, Murray & Hjort 41). The size of the "Thor" specimens is about equal for both sexes, up to 24 mm., thus not reaching the maximum hitherto known (30 mm., Bouvier).

At night, they were taken with 300—600 m.w., by day with 1600 m.w. This agrees very well with previous records; Murray and Hjort took 9 spec. by day at a depth of 500—1500 m., especially 500, but 32 at night, 50—1500 metres down, especially (24 spec.) 100—300 m. down. The 6 specimens mentioned by Bouvier were taken with 1200—3000 m.w. (daytime?).

Distribution. The species is not new to European

waters, having been previously taken at 35°13′ N, 8°06′ W (Monaco St. 2016, Bouvier). The other specimens mentioned by Bouvier were taken at 39°26′ N, 31°23½′ W, 0—1200 m.w. (st. 2212), 37°30′ N, 22°29′ W, 0—3000 m.w. (st. 2264), 36°17′ N, 28°33′ W, 0—3000 m.w. (st. 1849), and 27°36′ N, 38°29′ W, 0—2225 m.w. (st. 2087). — Those mentioned by Murray & Hjort and Sund 1920 were all taken between Europe and New Foundland. — 11° S, 19° W (St. Helena; Lenz & Strunck 1914).

3. GENNADAS VALENS S. I. Smith.

Amalopenæus valens Smith 1884, p. 402—04, Pl. 10 fig. 2.
Gennadas — Bouvier 1908, p. 28, 44 (lit.), Pl. 1 fig. 3 (cold. fig.), Pl. 9.
— — Murray & Hjort 1912, p. 668.
?*Amalopenæus* — Kemp, Ireland 1910, p. 19, textfig.
— — Sund 1920, p. 28.

Atlantic.

St. 71. 1150 m. 39°35′ N, 9°45′ W. 4-3-1909. 1600 m.w., 4^{00} pm., 120 min. 1 ♂ 28 mm. — **St. 91.** 1225 m. 35°53′ N, 7°26′ W. 18-6-1910. 1600 m.w., 5^{25} pm., 60 min. 16 spec.: 2 spec. 15—17 mm.; 4 ♂: 25, 27, 29, 31 mm.; 10 ♀: 21, 21, 23, 23, 31, 32, 33, 34, 34, 34 mm. — **St. 231.** 1000 m. 35°56′ N, 7°16′ W. 9-9-1910. 300 m.w., 1^{15} am., 30 min. 1 ♂ 27 mm. — **St. 232.** 3700 m. 36°28′ N, 9°06′ W. 9-9-1910. 300 m.w., 10^{35} pm., 30 min. 1 ♂ 33 mm., 1 ♀ 23 mm. — **St. 232.** ibid. 1000 m.w., 10^{35} pm., 30 min. 2 ♀ 33—36 mm. — **St. 232.** ibid. 2000 m.w., 11^{45} pm., 30 min. 12 spec.: 7 spec. 16—18 mm., 3 ♂ 27, 32, 33 mm., 2 ♀ 25—37 mm. — **St. 234.** 920 m. 38°10′ N, 9°20′ W. 10-9-1910. 300 m.w., 10^{30} pm. 1 ♂ 27 mm. — **St. 234.** ibid. 1000 m.w., 11^{20} pm., 30 min. 1 ♂ 34 mm.

M.W.	No. of hauls	
	Night	Day
300.....	3	—
1000.....	2	—
1600.....	—	2
2000.....	1	—

A coloured fig. see Bouvier Pl. 1, fig. 3. Murray & Hjort 1912, p. 668 give the colour as "coralline; bright blue patches. Eyes brown. Ratio of carapace to eyes 7.8".

The "Thor" material includes 36 specimens (12 ♂, 15 ♀, 9 jun.) from 5 stations, 8 hauls, all situated in the Bay of Cadiz. The species has formerly been taken on a single occasion (Monaco St. 2016, 1905, Bouvier).

Specimens less than 20 mm. can hardly be determined as to sex. The maximal size is 34 mm. for ♂, 37 for ♀. The largest size noted in extant works is 45 mm. for ♂, 35 mm. for ♀ (Bouvier) and 48 mm. for ♀ (?, Kemp).

Depth of sea 920—3700 m.

In the daytime, it was only taken with 1600 m.w.; at night, with 300—2000 m.w., especially 300(—1000) m.w. This agrees very well with previous records. Murray & Hjort have 98 specimens taken between Europe and Newfoundland (precise locality not stated). Of these, 88 were taken at night at a depth of 500—1500 m. below surface, but the 49 were taken 100—150 m. down. The ten specimens from day hauls were taken 500—1500 m. down, especially 500—1000 (8 spec.). — Bouvier has 21 specimens, all taken (by day?) with 1000—5000 m.w.

Distribution. 37°16½′ N, 74°20½′ W, 640 fms., 1 ♂ 38 mm. (Smith 1884). — Between New Foundland and Europe, 98 spec. (Murray & Hjort; Sund 1920). — 31°38½′—31°43′ N, 42°38′—42°40½′ W, 3 st., 0—1500 to 0—3000 m.w.; 33°41′ N, 36°35′ W, to 36°46′ N, 26°41′ W, 4 st., 0—2000 to 0—3250 m.w.; 31°06′ N, 24°06¾′ W, 0—5000 m.w.; 30°41′ N, 17°46′ W to 27°43′N, 18°28′ W, 3 st., 0—1000 to 0—3000 m.w.; 35°13′ N, 8°05′ W, 0—1800 m.w. (Bouvier 1908). — ?SW of Ireland 50°51½′ N, 12°8′ W, 0—480 fms. (Kemp 1910). — 17°28′ N, 29°42′ W; 0°46′ N, 18°59′ W; 11° S, 19° W; 35°39′ S, 8°16′ E (Lenz & Strunck).

4. GENNADAS SIMILIS n. sp. (Fig. 1).

Atlantic.

St. 65. 1300 m. 35°53′ N, 7°21′ W. 24-2-1909. 1600 m.w., 0^{30} pm., 120 min. 1 ♂ 38 mm. — **St. 71.** 1150 m. 39°35′ N, 9°45′ W. 4-3-1909. 600 m.w., 6^{35} pm., 120 min. 1 ♂ 39 mm., type. — **St. 231.** 1000 m. 35°56′ N, 7°16′ W. 9-9-1909. 300 m.w., 1^{15} am., 30 min. 1 ♂ 28 mm. — **St. 232.** 3760 m. 36°28′ N, 9°05′ W. 9-9-1910. 2000 m.w., 11^{45} pm., 30 min. 2 ♂ 34—35 mm. — **St. 234.** 920 m. 38°10′ N, 9°20′ W. 10-9-1909. 300 m.w., 10^{30} pm., 30 min. 1 ♂ 36 mm.

Description of the specimen from st. 71.

Length abt. 39 mm., carapace (incl. rostrum) 11.5 mm.

There are no podobranchiæ.

The dorsal and apical tooth of the rostrum rather long. Antennary and infra-antennary angles acute; branchiostegal spine present. The distance dorsally between the cervical and post-cervical grooves of the carapace is $^1/_5$—$^1/_6$ of the distance from the postcervical groove to the hinder margin. Median carina visible throughout the length of the carapace.

In the antennulæ the second joint in the peduncle dorsally is two-thirds the length of the third joint. Antennal plate a little more than three times as long as wide; the sides are not convex.

Second joint in mandibular palp as long as the greatest width of the first joint. In second maxilla the anterior lobe of the internal lascinia is not wider at the apex than at the base and is slightly narrower than the hinder lobe of the external lascinia. The endopod bears two (three?) curved spines and is rather broad.

In the first maxillipede the third joint in the endopod is twice as long and $1^1/_2$ time as wide as the second joint. There is a little terminal (fourth) joint. The basal joint bears four stiff spines, the proximal one somewhat longer and thinner than the other three. In the second maxillipede the merus is not twice as long (total length) as broad, the width is the same in both ends, and the part beyond the insertion of carpus is abt. one fifth the entire length of the merus. Dactylus has two strong apical spines.

In p. 1 carpus has the same length as the chela, or a little more than half as long as the merus. These proportions are the same in p. 2 except that carpus is two-thirds the length of the merus. In p. 3 the merus and carpus are of the same length; the chela is a little more than half the length of the carpus, and the dactylus a trifle shorter than the palm. First joint in p. 1 evenly rounded below.

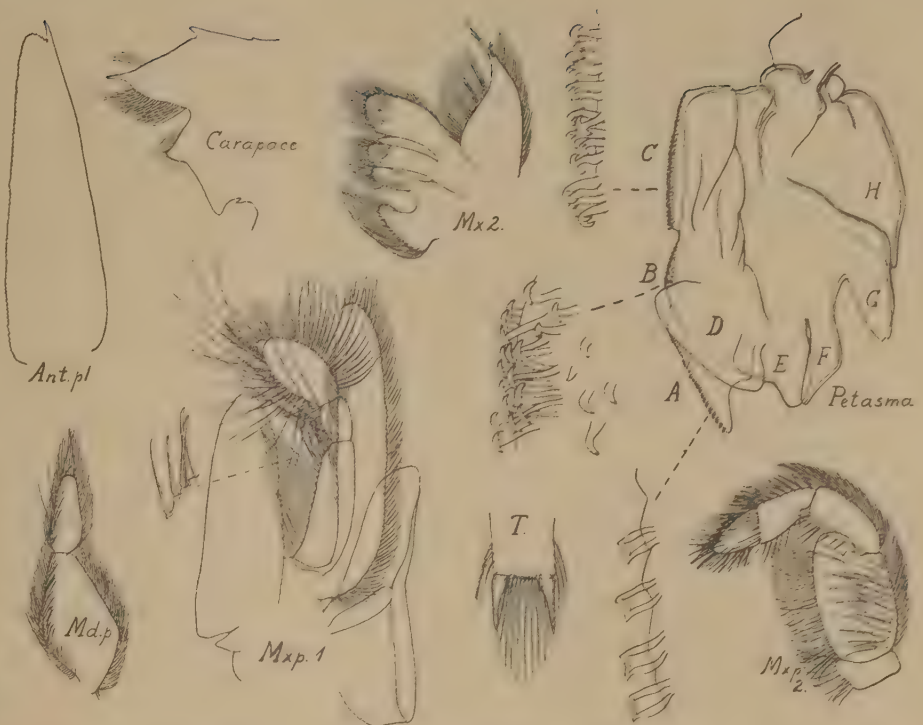

Fig. 1. Gennadas similis ♂. The setæ on the masticatory process of mxp. 1 are not drawn.

Only the sixth abdominal segment is dorsally carinate. Telson is truncate; between the two stout marginal spines it bears five pairs of plumose setæ.

The petasma is very characteristic. The median edge is longer than the other edges and ends distally in a long process with abt. 13 straight, stiff, stout spines (at A in the fig.), each of them being a little bifid in the apex. Proximally of these great spines some spines are situate, much lesser and shorter, but in very great number. At B and C in the fig. the spines are much thinner, but a little curvate and with the apex anchor-shaped, rendering it very difficult to part the two halves of the petasma from each other. At the distal part of the anterior side of petasma (this side turns toward the ventral side when the petasma lies in the natural position) is placed a lap (D in the fig.) which along with that of the other half of petasma lies between the much excavate parties of the ventral side at the basis of p. 5. The very characteristic shape of the processes E-H may be seen from the fig.

Among species hitherto described, the petasma of the present species mostly resembles that of *G. parvus* (Kemp 1909, Pl. 75, fig. 1) and *G. Alcocki* (Kemp, Indian Mus. 1910, Pl. 13, fig. 5), the lobes D—G being also found in these two species in similar form, only much smaller. On account of this similarity, I have named the present species *similis*. —

Occurrence, etc. There are altogether 6 ♂, (probably all adults) 28—39 mm. All were taken in the Bay of Cadiz; depth to bottom 920—3760 m.; taken with 300—2000 m.w. by night, with 1600 m.w. by day. No information as to colouring.

5. GENNADAS CHIASMIFERA n. sp. (Fig. 2—3).

Atlantic.

St. 65. 1300 m. 35°53′ N, 7°21′ W. 24-2-1909. 1600 m.w., 0^{30} pm., 120 min. 1 ♀ 34 mm. — **St. 71.** 1150 m. 39°35′ N, 9°45′ W. 4-3-1909. 600 m.w., 6^{35} pm., 120 min. 1 ♀ 39 mm. (carapace 12 mm.), type.

This species, extremely easy to distinguish by its thelycum, is so nearly allied to the *G. similis* ♂ above described that it might be taken for the ♀ of that species, were it not that the ♀ described below (*G. bidentata*) the ♂ of which is likewise unknown, approaches no less nearly to *G. similis*. I have therefore preferred to give

each ♀ its separate name, even though one of them may later be found to be ♀ to the ♂ above noted.

Apical joint in the mandibular palp narrower. In the first maxilliped the basal joint of the endopod bears three stiff spines. The third joint only $1^1/_2$ time as long and abt. $1^1/_4$ time as broad as the second joint. In the second maxilliped (fig. 2) the merus is broader in the distal than in the proximal end; the total length is $^5/_3$ the greatest width, and the part beyond the insertion of carpus is very great, $^1/_3$ as long as the total length of the merus. Dactylus has only one strong apical spine. First joint in p. 4 has at the underedge a single, rather stout tooth.

Fig. 2. Gennadas chiasmifera ♀. 2. Maxilliped (setæ omitted).

Thelycum (fig. 3) is composed anteriorly of a tongue-shaped broad process (between the two pereiopoda of third pair) with the apex turned backward, which along with the greater median process of the plate between the two pereiopoda of the fourth pair forms a hollow, very broad H or X; from this I have given it the name of *chiasmifera*. The plate between the two pereiopoda of the fourth pair is widest at the middle, very contracted toward the ends which again are somewhat broader than the narrow parties. Between the two pereiopoda of fifth pair lies a plate longer than broad, sending a tongue-shaped process toward the middle of the plate lying between the two pereiopoda of fourth pair. The posterior part of the plate is cleft into two ovular processes.

Fig. 3. Gennadas chiasmifera ♀, thelycum (St. 71, 1909, 600 m.w.)

Occurrence etc. Both specimens were taken at the Bay of Cadiz. The depth of the sea is 1150—1300 m. The vertical occurrence is: 600 m.w. (night) and 1600 m.w.(day).

6. GENNADAS BIDENTATA n. sp. (Fig. 4—5).

Atlantic.

St. 71. 1985 m. 57°47′ N, 11°33′ W. 7-6-1905. 1500 mw. 1 ♀ 48 mm. (carapace 15 mm.), type. — **St. 65.** 1300 m. 35°53′ N, 7°21′ W. 24-2-1909. 1600 m.w., 0^{30} pm., 120 min. 7♀24—27 mm. — **St. 71.** 1150 m. 39°35′ N, 9°45′ W. 4-3-1909. 600 m.w., 6^{35} pm., 120 min. 2 ♀ 34—39 mm.

Apart from its thelycum, this species is characterised by the two powerful teeth on the inferior margin of 1. joint in p. 4. For the rest, it is very closely allied to the above described ♂ and ♀ (*G. similis*, *G. chiasmifera*).

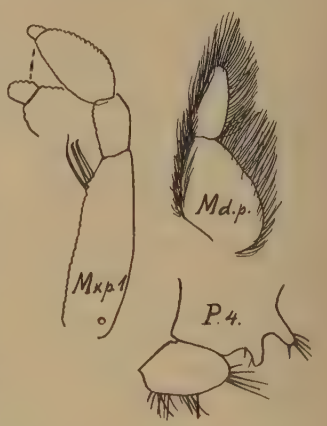

Fig. 4. Gennadas bidentata ♀. Mandibular palp, endopodite of 1. maxilliped, and 1.—2. joint of 4. pereiopod.

No podobranchiæ.

Differs from *G. similis* only in the following features:

The apical and dorsal tooth of the rostrum a little shorter. In the antennulæ the second joint in the peduncle dorsally is abt $^3/_4$ the length of the third joint. Both joints in the mandibular palp a little broader. The endopodite in second maxilla bears 4 curved spines. In the first maxilliped the basal joint of the endopodite bears 3 stiff spines. The second and third joints are as in *G. chiasmifera*, but fourth joint (the apical joint) relatively greater. The second maxilliped totally as in *G. chiasmifera*, thus somewhat differing from *G. similis*. Dactylus has one strong apical spine.

Fig. 5. Gennadas bidentata ♀, thelycum. (Fig. 71, 1905).

Both p. 1 and p. 2 are a little differing from the two above species, carpus being a little longer; in p. 1 the carpus is $^2/_3$, in p. 2 abt. $^4/_5$ the length of the merus. P. 3 as the two above species. 1. joint in p. 4 has the under edge 2 rather great teeth (hereof the specific name).

The thelycum (fig. 5) is very complicate. In the younger specimens the thelycum consists of the same principal parts, but these are lesser differentiate in details which especially applies to the fore edge of the great plate between the two pereiopoda of the fourth pair. In none of the specimens the thelycum is so highly developed in details as in the greatest specimen (fig.).

Occurrence etc. The type was found W. of N. Ire-

land, the other specimens in the Cadiz Bay. The depths of the sea were 1150—1985 m. At night is was taken with 600 m.w., at day with 1500—1600 m.w.

Genus Aristæomorpha Wood-Mason & Alcock.

Aristeomorpha Bouvier 1908, p. 52.
Aristæomorpha Stebbing, S. Afr. 1914, p. 24 (lit. and syn).

1. ARISTÆOMORPHA FOLIACEA Risso. (Fig. 6).

Aristeomorpha foliacea Bouvier 1908, p. 53 (lit. and syn.), Pl. 3 fig. 1 (cold. fig.), Pl. 11 figs. 1—5.
— — Sund 1920, p. 31.

Larva.
Aristeus antennatus Monticelli e Lo Bianco, Su la probabile larva di *Arist. antenn.*; Monit. Zool. Ital., Anno 13 (suppl.) Roma 1902[1] (*teste* Bouvier 1908, p. 53, 75).
— — Lo Bianco 1903, p. 184, Pl. 7 fig. 12 (cold. fig.).

Larvæ (and young stage).

Mediterranean.

St. 196. 660 m. 39°59′ N, 14°31′ E. 22-8-1910. 25 m.w., 2^{40} am., 30 min. 1 spec. 9 mm. — **St. 277.** ("Pangan"). > 3000 m. 33°20′ N, 27°30′ E. 6-4-1911. 132 m.w., 11^{35} pm., 35 min. 1 spec. 10 mm. — **St. 340.** ("Pangan"). > 2000 m. 35°50′ N, 21°30′ E. 26-8-1911. 108 m.w., 9^{00} pm., 30 min. 1 spec. 10 mm. — **St. 384.** ("Pangan"). > 3000 m. 32°50′ N, 27°10′ E. 7-11-1911. 122 m.w., 9^{00} pm., 30 min. Young stage, 9 mm.

Atlantic.

St. 376. ("Florida"). > 3500 m. 34°41′ N, 16°14′ W. 22-7-1911. 15 m.w., 8^{45} pm., 30 min. 3 spec. abt. 9 mm. — **St. 376.** ibid. 30 m.w., 8^{40} pm., 30 min. 2 spec. 7—8 mm.

Of this species which is a bottom form, living in a depth of 400—1300 m., the "Thor" has not taken the adult stage.

On the other hand the material contains some larvæ (Mysisstage) and a young stage. The length is 7—10 mm.

I have not had access to Monticelli and Lo Bianco's original description of the larva of 1902; but 1903 Lo Bianco has given a short description and a coloured figure of the larva in dorsal view. The larvæ from the "Thor" agree so well with Lo Bianco's larva that there cannot be doubt that the larvæ are identic; but a few things may be added or corrected in his description, and I give some detail figures in order to complete his habitus figure.

The rostrum has at the dorsal side 2 or (in the elder specimens) 3 teeth. A little notch is placed in the dorsal middle line of the carapace somewhat behind the rostrum. There is a spine above the eye and on the anterior under edge of the carapace; hepatic spine present. All the specimens have chelæ at p. 1—p. 3. The antennal plate

Fig. 6. Aristæomorpha foliacea, larva 9 mm ("Thor" St. 196). Rostrum, ant. 2, the last abdominal segments and caudal fan. (All drawn to the same scale).

has no apical tooth; but a spine is placed at the middle of the side edge, not at the anterior third part as in Lo Bianco's fig. The sixth abdominal segment has at its under edge 4 or (in the elder specimens) 5 pairs of spines. The telson has in the hook inside the great apical spines abt. 16 pairs of lesser spines. The peduncle of the uropods ends with two teeth; the outer ramus is rather broad toward the apex and ends in a rather long apical tooth.

The colour cannot be seen from the "Thor"-specimens; it is whitish (hyaline?) with red and orange spots (Lo Bianco's cold. fig.).

The young stage has lost all the spines at the dorsal side of the abdomen except that on the 6th segment, now very little; but all the other spines on the abdomen are present. —

The depths of the sea are 660—> 3500 m., thus much greater than the depths for the adult (400—1300 m.);

[1] I have not had access to this paper.

all the specimens were taken during the night, 15—132 m.w.

Distribution. 1. Mediterranean. Nizza, Napoli, Palermo, Messina, N. Africa 725 m., Sea of Candia 808—1242 m.; 37°53′—39°58½′ N, 9°27¾′—11°56½′ E, 4 stations, 395—860 m. (Senna 1903). — W. of Cape Scalambri, Sicilia, 618 m. (Bouvier).

2. Atlantic. W. of Casablanca, Morocco, 851 m. (Bouvier). — Bay of Cadiz, 535 m. (Sund 1920). — ?Bay of Darien (N. of Panama) (Smith 1885).

3. Indic. ?Bay of Bengal (*A. giglioliana* Wood-Mason?, *teste* Bouvier 1908).

Genus Solenocera Lucas 1850.

Solenocera Bouvier 1908, p. 86.

1. SOLENOCERA SIPHONOCERA Phil.

Solenocera membranacea Bouvier 1908, p. 87 (lit. and syn.).

siphonocera Kemp, Ireland 1910, p. 20 (lit. and syn.), Pl. 2.

– *membranacea* Pesta 1918, p. 36 (lit.), figs. 3—5.

The larva.

Solenocera siphonocera Monticelli & Lo Bianco 1900.*

— — Uova e larve di *S. s.* Monit. Zool. Ital., Anno 12, 1901, p. 205.*

Lo Bianco 1902, p. 437.

1903, p. 183.

— — 1904, p. 32, figs. 39—40 (cold. figs.).

Penæus siphonocerus Williamson 1915, p. 340, figs. 8—9.

Adult stage.

St. 213. 75 m. 40°14′ N, 0°54′ E. 31-8-1910. Monaco-trawl, 6 spec., 38—abt. 75 mm.

Larvæ.

Mediterranean.

St. 98. 775 m. 35°57′ N, 5°35′ W. 23-6-1910. 65 m.w., 6^{35} pm., 15 min. 2 spec. — **St. 104.** 250 m. 36°37′ N, 2°04′ W. 24-6-1910. 65 m.w., 6^{20} pm., 30 min. Abt. 15 spec. — **St. 106.** 1150 m. 36°33′ N, 2°00′ W. 25-6-1910. 65 m.w., 2^{30} am., 30 min. 4 spec. — **St. 106.** ibid. 300 m.w., 1^{45} am., 30 min. Abt. 10 spec. — **St. 107.** 2000 m. 36°13′ N, 1°28′ W. 25-6-1910. 65 m.w., 9^{50} am., 15 min. Abt. 10 spec. — **St. 107.** ibid. 300 m.w., 9^{05} am., 30 min. 2 spec. — **St. 108.** 2435 m. 36°03′ N, 0°27′ W. 25-6-1910. 300 m.w., 10^{30} pm., 30 min. 3 Zoeæ, abt. 10 Mysis st. — **St. 108.** ibid. 2000 m.w., 0^{40} am., 60 min. 2 spec. — **St. 112.** 2700 m. 36°56′ N, 2°15′ E. 27-6-1910. 25 m.w., 1^{30} am., 15 min. 1 spec. — **St. 113.** 815 m. 36°53′ N, 3°09′ E. 28-6-1910. 300 m.w., 3^{25} am., 30 min. 4 spec. — **St. 123.** > 600 m. 44°14′ N, 8°55′ E. 3-7-1910. 25 m.w., 1^{50} am., 15 min. 7 spec. — **St. 123.** ibid. 65 m.w., 0^{55} am., 30 min. Abt. 60 spec. — **St. 124.** 86 m. 44°20′ N, 9°05′ E. 3-7-1910. 65 m.w., 3^{30} am., 90 min. Abt. 35 spec. — **St. 126.** 600—620 m. 42°43′ N, 9°50′ E. 10-7-1910. 300 m.w., 9^{30} pm., 30 min. 5 spec. — **St. 132.** 1227 m. 38°57′ N, 9°47′ E. 14-7-1910. 600 m.w., 4^{50} am., 30 min. 1 spec. — **St. 139.** 530 m. 37°57′ N, 11°54′ E. 20-7-1910. 300 m.w., 2^{35} am., 30 min. 1 spec. — **St. 143.** 1842 m. 35°18′ N, 16°25′ E. 23-7-1910. 25 m.w., 1^{20} am., 30 min. 1 spec. — **St. 143.** ibid. 300 m.w., 0^{30} am., 30 min. 2 spec. — **St. 143.** ibid. 1000 m.w., 2^{00} am., 60 min. 2 spec. — **St. 174.** 120 m. 40°54′ N, 28°53′ E. 11-8-1910. 65 m.w., 11^{50} am., 30 min. Abt. 100 spec. — **St. 175.** 1103 m. 40°48′ N, 27°59′ E. 11-8-1910. 400 m.w., 11^{20} pm., 30 min. 4 spec. — **St. 175.** ibid. 1200 m.w., 0^{25} am., 30 min. 1 spec. — **St. 176.** 560 m. 40°45′ N, 27°43′ E. 12-8-1910. 65 m.w., 4^{00} am., 30 min. Abt. 40 spec. — **St. 192.** 650 m. 38°07′ N, 15°35′ E. 20-8-1910. 600 m.w., 10^{50} pm., 30 min. 1 spec. — **St. 195.** 3160 m. 39°02′ N, 14°55′ E. 21-8-1910. 65 m.w., 6^{50} pm., 15 min. 1 spec. — **St. 206.** 2782 m. 39°32′ N, 5°15′ E. 28-8-1910. 300 m.w., 1^{05} am., 15 min. 1 spec. — **St. 209.** > 2000 m. 40°34′ N, 3°03′ E. 28-8-1910. 150 m.w., 4^{25} am., 20 min. 4 spec. — **St. 209.** ibid. 2000 m.w., 7^{25} am., 45 min. 1 spec. — **St. 210.** 775 m. 41°10′ N, 2°23′ E. 30-8-1910. 600 m.w., 3^{35} am., 30 min. 5 spec. — **St. 217.** > 2000 m. 38°01′ N, 1°48′ E. 1-9-1910. 300 m.w., 1^{40} pm., 30 min. 2 spec. — **St. 279.** 350 m. Messina-Straits. 23-2 1911. 300 m.w., 9^{30} pm., 150 min. 1 spec.

Atlantic.

St. 1. 94 m. 49°17′ N, 4°13′ W. 28-11-1908. 25 m.w., 2^{50} am , 30 min. 1 spec. — **St. 93.** 40 m. 36°17′ N, 6°17′ W. 22-6-1909. 50 m.w., 9^{20} pm., 30 min. 1 spec. — **St. 95.** 275 m. 35°57′ N, 6°00′ W. 23-6-1909. 65 m.w., 5^{50} am., 30 min. Abt. 10 spec. — **St. 96.** 190 m. 35°48′ N, 5°58′ W. 23-6-1909. 65 m.w., 9^{30} am., 30 min. 1 spec.

* I have not had access to this paper.

A. Mediterranean.

The adult stage was taken in some few specimens at one station between the Baleares and Spain.

The larvæ (*"Opisthocaris"*) were taken at a number of stations from the straits of Gibraltar to Constantinople; all the specimens from the "Thor" belong to the Mysis stage except 3, being Zoeæ.

I have not had access to Monticelli and Lo Bianco l. c. 1900 and 1901. Lo Bianco (1902, 1904) writes that the species is pubescent during the whole of the year, and the larvæ may (at Capri) be taken the whole summer to a depth of 300 m. below surf. while they at the other seasons may also be taken at the surface. Of this species (as also of *Sicyonia*) Lo Bianco has taken the whole series of development from the ova to the young stage.

Below we shall see the results from the "Thor".

All the specimens were taken in summer (June 23. to Sept. 1.) except one spec. in Feb.

Depths of the sea and occurrence. Almost all the larvæ were taken in the western basin; only some few stations lie in the eastern basin: 2 in the Messina-Straits, 1 SE of Sicilia, 3 in the Marmora Sea.

Depths in m.	No. of stations
0— 250.....	3
>250— 500.....	2
>500—1000.....	7
>1000—2000.....	5
>2000—3000.....	5
>3000.....	1

The depths of the sea are especially >500—3000 m., almost only >500—1000 m. 3 stations have depths 0—250 m., *viz.* 86, 120 and 250 m. Thus numerous larvæ were taken at depths much greater than those where the adult are most frequent (abt. 50—700 m.).

Vertical occurrence.

M.w.	Night				Day
	Hauls	Duration in hours	No. of spec.	No. of spec. pr. hour	No. of hauls
25	3	1	9	9	—
65	8	4.5	257	57.1	1
150	1	0.33	4	12	—
300— 400	9	6.25	41	6.6	2
600—2000	6	4	12	3	1
total...	27		323		4

We see that during the night most of the specimens were taken with 65 m.w., the numbers pr. hour diminishing both upward and downward.

In the day-time there were only 4 positive hauls (65—2000 m.w.).

B. Atlantic.

The larvæ were taken only at four stations: one (st. 1) in the Channel, the other outside Gibraltar. The depths of the sea were 40—275 m., the depths below surf. (night) 25—65 m.w.; day-time (1 haul): 65 m.w.

Distribution.

1. Mediterranean. The species is common especially between 60 and 200 m. (Kemp, Ireland 1910) and lives on sandy or muddy bottom (Pesta 1918). Alger, Marseille, Nizza, Genova, Napoli, Sicilia (Carus 1885). — Adria from Fiume to Otranto (Pesta 1918). — "Thor" st. 213, inside the Baleares. — 39°58′ N, 9°48′ E, 395 m. (Senna 1903). — 35°48′ N, 23°34′ E, 755 m.; 35°59′ N, 22°56′ E, 660 m.; southern Adria 7 stations 42°32¼′—40°32¾′ N, 15°22½′—18°58′ E, 104—760 m. (Adensamer 1898). —

2. Atlantic. SW. Ireland, 8 st., 100—>1000 m. (Calman 1896, Bouvier 1908, Kemp, Ireland 1910). — Bay of Biscay, >400 m. (Caullery 1896). — Açores, 500 m. (Bouvier 1908). — Morocco (Milne-Edwards 1882). — Venezuela: Paria, 60 m. (Smith 1885).

Genus Funchalia Johnson.

Funchalia Bouvier 1908, p. 91 (lit. et syn.).

1. FUNCHALIA WOODWARDI Johnson.

Funchalia Woodwardi Bouvier 1908, p. 93 (lit. and syn.), Pl. 1 fig. 7 (cold. fig.), Pl. 15, Pl. 16 figs. 1—8.
" " Lenz & Strunck 1914, p. 303—06, Pl. 16, Pl. 17 figs. 1—19.
— Murray & Hjort 1912, p. 668.
— — Sund 1920, p. 32.
Grimaldiella Richardi (postlarval stage) Bouvier 1908, p. 96, Pl. 16 figs. 9—21.

On the probable larva, see Penæid-larva No. 4 (p. 26).

Mediterranean.

St. 24. >3700 m. 40°14′ N, 12°23′ E. 16-1-1909. 25 m.w., 10^{00} pm., 30 min. 1 spec. 28 mm. — **St. 28.** 600 m. 40°53′ N, 13°43′ E. 19-1-1909. 100 m.w., 10^{00} pm., 60 min. 1 spec. 42 mm. — **St. 38.** >75 m. 40°45′ N, 9°30′ E. 31-1-1909. 25 m.w., 7^{10} pm., 30 min. 1 spec. 24 mm. — **St. 130.** >3000m. 39°35′ N, 11°20′ E. 13-7-1909. 25 m.w., 0^{50} am., 30 min. 1 ♀ abt. 80 mm. — **St. 132.** 1227 m. 38°57′ N, 9°47′ E. 14-7-1909. 25 m.w., 3^{05} am., 30 min. 1 ♂ abt. 70 mm. — **St. 132.** ibid. 300 m.w., 3^{45} am., 30 min. 1 ♂ abt. 55 mm. — **St. 144.** 3340 m. 34°31′ N, 18°40′ E. 24-7-1910. 25 m.w., 2^{00} am., 30 min. 1 ♀ 45 mm. — **St. 194.** 1140 m. 38°33′ N, 15°29′ E. 21-8-1910. 1200 m.w., 6^{00} am., 30 min. 1 spec. 24 mm.

Atlantic.

St. 65. 1300 m. 35°53′ N, 7°28′ W. 24-2-1909. 1600 m.w., 5^{30} pm., 120 min. 1 ♂ 55 mm. — **St. 231.** 1000 m. 35°56′ N, 7°16′ W. 9-9-1910. 25 m.w., 0^{15} am., 30 min. 2 ♀ abt. 50—55 mm. — **St. 232.** 3730 m. 36°28′ N, 9°06′ W. 9-9-1910. 25 m.w., 8^{50} pm., 30 min. 5 spec.: 3 ♂ abt. 50 mm., 2 ♀ abt. 45—50 mm. — **St. 232.** ibid. 300 m.w., 10^{35} pm., 30 min. 1 ♀ 67 mm.

Of this species, the "Thor" took 17 specimens in all, to wit, in the Mediterranean, 8 specimens in 8 hauls at 7 stations, in the Atlantic, 9 specimens in 4 hauls at 3 stations.

In the Mediterranean, all the stations lie in the western basin, with the exception of a single one (St. 194) in the western part of the eastern basin; in the Atlantic,

only in the Bay of Cadiz. Depth to bottom over 75—3730 m., for the most part over 1000 m. In the night hauls, nearly all specimens were taken with 25 m.w. (300—1200 m.w. at the outside); in the daytime there is a single haul with 1600 m.w. That the species is chiefly found at the surface during the night agrees with the fact that it is almost colourless, only with a faint reddish tinge (Bouvier p. 96, Pl. 1, fig. 7; Murray & Hjort p. 668); larger specimens, however, may be of a more pronounced red (Bouvier p. 96).

The "Thor" results in regard to vertical occurrence agree very well with previous records, though a single specimen has been taken with greater length of line (Bouvier). The only great amount of material mentioned in the literature is cited by Murray and Hjort; it comprises 62 specimens, of which 55 taken at night at a depth of 50—1500 m., though the great majority (45 spec.) were taken at a depth of 50—150 m. In the daytime, it was taken at similar depth.

Distribution. 1. Mediterranean. New to this sea, see on the "Thor" above.

2. Atlantic. At Europe not N. of $36^1/_2°$ N ("Thor"). — Between Europe and New Foundland (Murray & Hjort 1912; Sund 1920). — 37°28′ N, 25°53′$^1/_2$ W, 0—1000 m., 3 spec.; 36°46′ N, 26°41′ W, 0—3250 m., 2 spec.; 31°06′ N, 24°06$^3/_4$′ W, 0—5000 m., 2 spec.; 30°48′ N, 25°18$^1/_4$′ W, surf., 1 spec. (Bouvier). — Madeira, 1 spec. (Johnson, *teste* Bouvier). — W. of Canaries, surf., night 2 spec.; 30°2′ S, 14°21′ W, 10 m. below surf., 5 spec. (Lenz & Strunck).

Genus Parapenæus Smith.

Parapenæus Bouvier 1908, p. 101.

1. PARAPENÆUS LONGIROSTRIS Lucas = PENÆUS MEMBRANACEUS Heller.

Parapenæus longirostris Bouvier 1908, p. 102 (lit. and syn.).
— — Pesta 1918, p. 42 (on lit. and syn.), figs. 8—9.

Mediterranean.

St. 174. 120 m. 40°54′ N, 28°55′ E. 11-8-1910. Dredge. 1 spec., 70 mm.

This species, whose colour is whitish with pink spots (Bouvier l. c., note p. 105), is a bottom-form which belongs to the sublittoral zone, 50—400 (629) m. — On the larva, see below.

Distribution. 1. Mediterranean. Alger, Cette, Nizza, Genova, Napoli, Sicilia, Palermo (Carus 1885). — Capri; Salina (Eolian Islands) (Lo Bianco 1902, 1903, 1904). — W. of Sicilia, 224 m. (Bouvier 1908). — Capo Carbonaro (S. E. Sardinia), 508 m.; W. of Sicilia, 400 m. (Senna 1903). — Valencia (Bolivar, *teste* Bouvier 1908). — N. of Crete, 3 stations, 287—629 m.; W. of Cyprus, 2 st., 315—390 m. (Adensamer 1898). — Marmora Sea ("Thor" st. 174). — Adria: Durazzo, 120 m., yellow mud, 1 spec.; not Zara and Ragusa [*Solenocera membranacea*] (Pesta 1918, p. 44—46).

2. Atlantic. From Portugal to Morocco (Bouvier 1908). — Cadiz Bay, 535 m. (Sund 1920).

Larva and young stage.

Penæus membranaceus Monticelli & Lo Bianco, Monit. Zool. Ital., vol. 12, 1901, p. 198—200 (Mysis).
— — Lo Bianco 1902, p. 437 (young stage).
— — 1903, p. 183 (Mysis).
— — 1904, p. 31, fig. 38 (cold. fig., young stage).
?*Penæuslarve* Claus 1876, p. 41, Pl. 3 figs. 7—8.

Atlantic.

St. 376 ("Florida"). > 3500 m. 34°41′ N, 16°14′ W. 22-7-1911. 15 m.w., 8^{45} am., 30 min. 4 spec. 10—12 mm.
St. 377 ("Florida"). > 4300 m. 31°23′ N, 18°08′ W. 23-7-1911. 15 m.w., 8^{05} pm., 30 min. 4 spec. 10—16 mm.

The present larva, which in addition to the rostrum and caudal spines is characterised by an enormous outer ramus in the urop., agrees well with Claus' fig. save for the presence of a distinct hepatic spine.

The smallest specimens are abt. 10 mm. Even at this stage, all five pairs of pereiopoda are indicated, but greatly decreasing in size toward the hinder part. No true chelæ on p. 1—3. Pleopoda quite small, but cleft. The largest specimens (16 mm.) answer to the stage shown in Claus' figure. The caudal fan is uniform throughout all stages.

Literature and determinations. While the young stage has been well portrayed and comparatively well described (vide supra, under Literature), this cannot be said of the larva. The only real description is given (without figure) by Monticelli and Lo Bianco l. c. 1901, and this is not particularly good. It ends, however, with the statement that the mysis stage greatly resembles ("mostra molta rassomiglianze con") the undetermined larva described and figured by Claus l. c.

As the larvæ taken by the "Thor" are identical with that described by CLAUS, there is thus a certain probability of their being really those of *Parapenæus longirostris*.

The young stages of *Parapenæus longirostris* (10—40 mm.) live as a rule in the cloaca of *Pyrosoma*, very rarely free-swimming, and are hyaline, whitish with yellow spots (Lo Bianco 1902, 1904 fig. 38, col. fig.). The older specimens are pale yellow (PESTA 1918).

Distribution. (Of CLAUS' larva) Atlantic, precise locality not stated, up to 16 mm. long (CLAUS). Indian Ocean 27°—29° S, $62^1/_2$°—$65^1/_2$° E, CASPERSEN 1869, 1 spec. (The specimen in our Zool. Museum)

Genus Sicyonia M.-Edw.

Sicyonia Milne-Edwards 1830, p. 339.
Eusicyonia Stebbing, S. Afr. 1914, p. 25 (lit. and sgn.).

1. SICYONIA SCULPTA M.-Edw.

Adult stage.

Cancer carinatus Olivier, Zool. Adriat., Pl. 3 fig. 2 (*teste* HELLER 1863).
Sicyonia sculpta H. Milne-Edwards 1830, p. 339, Pl. 9 fig. 1—8.
— — Heller 1863, p. 291 (lit. and syn.).
— — Bate 1888, p. 294, Pl. 43 fig. 1.
— *carinata* Pesta 1918, p. 47 (lit. and syn.), figs. 10—12.
non — — H. Milne-Edwards 1830, p. 344, non *S. c.* Sp. Bate 1883 (*teste* DE MAN 1911, p. 111).

Larval development.

Sicyonia sculpta Monticelli & Lo Bianco 1900.[1]
— — Lo Bianco 1902, p. 436, 438.
— — — 1904, p. 29, 31.

Mediterranean.

St. 17. 19 m. 37°49′ N, 23°27′ E. 30-12-1908. Dredge. 1 spec. 23 mm.

This species which (like the genus, to which it belongs) differs from the other Penæids in its strong sculpture, is a bottom form; it lives in rather shallow water, 4 m. and downwards, between algæ and stones or at sandy bottom with *Zostera* (PESTA l. c.). The body is spotted with brown (PESTA).

[1] I have not had access to this paper.

Larval development. GRAEFFE (Arb. Zool. Inst. Wien, Bd. 13, 1900, p. 65) states that the spawning time is May—June, perhaps also the autumn; but PESTA (1918, p. 49) cannot find a confirmation of this neither in the literature nor in the material.

I have not had access to MONTICELLI and LO BIANCO's original description of the larva 1900; figures of the larva do not seem to exist. LO BIANCO (1902—1904) says only that the larva very much resembles that of *Gennadas elegans* (the larvæ of *Amalopenæus elegans* "erinnern . . in ihren Gesammthabitus sehr an diejenigen von *Sicyonia sculpta*"), and that the whole series of development from ova to the Mysis-stage may be found in the plankton at Naples.

Distribution. 1. Mediterranean. The species does not seem to be very common in the Mediterranean, but is found at several localities. Messina (RIGGIO 1905, p. 18). — Naples (LO BIANCO l. c.). — Mers-el-Kebir, Alger, Bone; Genova; Isola Maddalena; Naples; Sicilia: Palermo, Messina, Catania; Reggio di Calabria (CARUS 1885). — Adria: Trieste, Lesina, Naples, Messina (specimens in Zool. Museum). — Several localities in the Adriatic (see PESTA 1918). — Gulf of Aegina ("Thor" st. 17).

2. Atlantic. Cap Verde; Senegambia (PESTA 1918).

On the Development of the Penæidæ.

The development of the *Penæidæ* is altogether somewhat indifferently known (see WILLIAMSON 1915 p. 335). The larvæ are known by having chelæ on the three anterior pairs of pereiopoda.

Of the species from the "Thor" area, there are only the following species whose development is at all known, and all these are found in the Mediterranean.

Gennada elegans, see below [Penæidlarva No. 1], p. 21.
Aristeomorpha foliacea (=*Aristeus antennatus* Mont. & Lo B.), see p. 15.
Solenocera siphonocera (p. 16).
Funchalia Woodwardii (postlarval stage, p. 17).
Parapenæus longirostris (p. 18).
Penæus caramote (young stage: P. MAYER, Mitt. Zool. Stat. Neapel vol. 1, 1878, p. 49—51).
Sicyonia sculpta (p. 19).

Of the species from the "Thor" area, the determination appears to be absolutely certain only in the case of *Solenocera*, this being the only species in which the development is known from the egg to the young.

The same applies, it is true, also to *Gennadas elegans*, but the only extant description is not particularly good,

and is not accompanied by any figure, so that the larvæ can hardly be recognised with any degree of certainty from this. It is possibly identical with the larva called *Euphema armata* (vide infra, Penæid larvæ No. 1).

Parapenæus longirostris has been hatched out by Monticelli and Lo Bianco, who managed to keep it alive through several stages; the transition from the Mysis stage to the young, however, they did not succeed in obtaining. In regard to this, the same applies as in the case of *Gennadas elegans*: the description of the larva is not accompanied by any figure. See also under *Parapenæus longirostris* (supra, p. 18).

In addition to these, there are also known larvæ which are referred to *Aristeomorpha foliacea* and *Sicyonia sculpta*; the reason for attributing the first larva to the species in question is not apparent from the description, whereas in the case of *Sicyonia*, we have the entire development from egg to Mysis.

The larva of *Sicyonia* shows, "in its total habitus, a great resemblance" to those of *Gennadas elegans* (Lo Bianco 1904 p. 29), no other description is given, nor any figure; I have not, however, had access to Monticelli's and Lo Bianco's original description of 1901, so that I do not known whether the larva is there more fully described.

Quite apart from the fact that the determinations in literature of several of the larvæ are perhaps not always certain, the works in question (or at least those I have been able to consult) do not always give a sufficiently good description to enable one to recognise a larva.

The Penæide larvæ above mentioned (determined or undetermined) are, as far as I can see, the only ones mentioned in literature from the area covered by the "Thor".

"Thor" Expedition. The material from the "Thor" includes larvæ (and some young stages) of 6 *Penæidæ* in all. Of these, *Aristeomorpha foliacea* and *Solenocera* can with certainty be referred to the extant descriptions and figures. The larvæ of *Parapenæus longirostris* (vide supra p. 18) is perhaps rightly determined, and 2 can with a fair degree of certainty be referred to larvæ already described which have not been ascribed to any definite adult species, viz. *Euphema* (*armata*?) and *E.* (*polyacantha*?) (Larvæ Nos. 1—2). There remain 2 (Larvæ Nos. 3—4) which are altogether new to science, but which can nevertheless be determined with some degree of certainty.

Three of these larvæ (Nos. 1, 3 and 4) were found in the Mediterranean, the corresponding adult forms must therefore be sought for among the 8 species known from that sea.

Of these 8 species, we have good descriptions of the larvæ only in the case of two; viz. *Aristeomorpha foliacea* and *Solenocera*, larvæ of both these species were taken by the "Thor" and are noted together with the adults. Of the remaining 6 species, the larvæ of 3, (*Aristeus antennatus*, *Funchalia Woodwardii*, *Penæus caramote*) have never been described, and in 3 cases (*Gennadas elegans*, *Parapenæus longirostris* and *Sicyonia sculpta*) only described in such a manner (and without figure) that they are hardly to be recognised with certainty. (An attempt has been made, however, to refer one of the larvæ to *Parapenæus*). The three undetermined larvæ taken by the "Thor" in the Mediterranean must thus belong to three of the last mentioned six species: ÷ *Parapenæus*; an andeavour is made in the following to determine them.

Larva No. 1. (*Euphema* [*armata*?]) was found in great numbers both in the Mediterranean and the Atlantic and must thus belong to a species common in both seas; this would hardly apply to any other than *Gennadas elegans*. The question then is: does it answer to the description of the larva of this species?

Unfortunately, the original description of *Gennadas elegans* larva (Monticelli and Lo Bianco 1900) was not available for reference, so that I only know the description from Williamson's account of the same (1915 p. 343—44) which is not clear in all points, besides lacking figures. It is here stated that Zoea has "kräftige dorsale Stackeln nach dem Abdominalsegment", which is hard to understand. For the rest, the description might agree fairly well with Claus' figure (Claus 1876, Pl. 3, fig. 2) of *Euphema armata*, to which W. refers; but whether this is really the larva in question it is hard to decide with certainty. The mysis-stages (and there are no others in the "Thor" material) are said to be furnished with "four long anterior spines on the sides of the thick median point" (= rostrum). This might perhaps fit, as there is both a supra-ocular spine and a spine on the lower anterior margin of the carapace. The zoea stages are said to have small spines on the sides of 4 and 5 caudal segment; the "Thor" has no zoea stages, but the mentioned spines are not found in the "Thor" material, which consists exclusively of mysis stages, and we cannot see from Williamson's text whether they are also present in the mysis.

It is impossible, then, to determine with certainty whether the larva from the "Thor" belongs to *Gennadas elegans*, though much would appear to indicate that this is the case.

According to Lo Bianco 1904, p. 29, the larva of *Gennadas elegans* should be very similar to that of

Sicyonia sculpta; it is therefore not impossible that the larva belongs to this species, though on the other hand its great frequency would seem to contradict this.

Larva No. 4. probably belongs to *Funchalia Woodwardii*; in the two oldest specimens, the telson is altogether similar in form, and in the arrangement of spines on the posterior margin, to that of the postlarval specimens (see Bouvier 1908, Pl. 16 fig. 21) while the presence of an hepatic spine also renders it likely that it belongs to a species having this spine in the adult stages. On the other hand, it must be pointed out that md. even in the largest specimen, has no approximation to the elongated form found even in the young stages.

Larva No. 3. If the above observation are correct, there remain then the following Mediterranean species having larvæ unknown: *Aristeus antennatus*, *Penæus caramote* (and *Sicyonia sculpta*), and Larva No. 3 must probably belong to one of these; *Sicyonia*, however, is probably out of the question (vide supra under Larva No. 1). Which of these species it does belong to can hardly be determined at the moment, though it seems most likely that it should be *Penæus caramote*, owing to the comparatively numerous teeth on the upper margin of the rostrum, for the adult *Aristeus antennatus* has only three such teeth, whereas *Penæus caramote* has 10 or thereabouts. On the other hand, the hepatic spine is lacking, both in the larva and in *Aristeus*, while it is present in *Penæus*.

Larva No. 2 *(Euphema [polyacantha?])* This larva was only taken in the Atlantic, not in the Mediterranean; it is therefore probable, if not certain, that it belongs to a species only found in the Atlantic. There is, however, no description of a larva belonging to any of the 10 species only found in the Atlantic, and the larva from the "Thor" does not seem to present any characters offering any particular indication to aid in the determination. If, however, the observations in the foregoing are correct, and Larva No. 1 (*Euphema [armata?]*) should properly be ascribed to one of the *Gennadas* species, there may be reason to believe that *Euphema* (*polyacantha?*) is the larva of one of the *Gennadas* species which do not penetrate into the Mediterranean, since I take it for granted that *Euphema* can be maintained as a genus, though it does not, it is true, comprise any adult forms, but only larvæ.

Euphema M.-Edw.

(Penæid-larvæ Nos. 1—2).

Euphema H. Milne-Edwards 1837, p. 420.
— Ortmann 1894, p. 76.

Penæid-larva No. 1. (Fig. 7).

Euphema (armata M.-Edw.?) = ?larva of Gennadas elegans Smith

(see p. 20).

?*Euphema armata* H. Milne-Edwards 1837, p. 421.
Penæus-Larve Claus 1876, p. 41—43 (partim), Pl. 3 fig. 6, figs. 1, 3—5?, not fig. 2.
?*Aristæus-larva* Bate 1888, p. 239, Pl. 47 fig. 2.
?*Euphema armata* Ortmann 1893, p. 76.
?*Amalopenæus elegans, larva* Monticelli & Lo Bianco 1900.[1]
? — — — Lo Bianco 1902, p. 435.
? — — — 1904, p. 29.
? — — — Williamson 1915, p. 343.

Mediterranean.

St. 11. > 3700 m. 36°57′ N, 18°16′ E. 16-12-1908. 25 m.w., 60 min., 4^{00} am. 3 spec. 4, 4, 6 mm. — **St. 35.** 200 m.w., 6^{40} am., 60 min. 1 spec. 6 mm. — **St. 40.** 235 m. 39°10′ N, 9°40′ E. 1-2-1909. 65 m.w., 9^{30} pm., 30 min. 1 spec. 8 mm. — **St. 43.** > 2000 m. 38°14′ N, 8°42′ E. 3-2-1909. 65 m.w., 6^{15} am., 30 min. Abt. 60 spec. 4—7 mm. — **St. 53.** 2600 m.w., 5^{15} pm., 90 min. 1 spec. 7 mm. — **St. 55.** 75 m. 36°46′ N, 2°18′ W. 19-2-1909. 25 m.w., 6^{30} am., 60 min. 3 spec. 8 mm. — **St. 99.** 750 m. 36°02′ N, 5°16′ W. 24-6-1910. 65 m.w., 0^{10} am., 15 min. 1 spec. 6 mm. — **St. 99.** ibid. 300 m.w., 11^{25} pm., 30 min. 3 spec. 4—6 mm. — **St. 105.** 20 m. 36°43′ N, 2°08′ W. 24-6-1910. 40 m.w., 7^{45} pm., 15 min. 3 spec. 4—7mm. — **St. 106.** 300 m.w., 1^{45} am., 30 min. 10 spec. abt. 7 mm. — **St. 106.** ibid. 1200 m.w., 0^{20} am., 60 min. 1 spec. 8 mm. — **St. 107.** 65 m.w., 9^{50} am., 15 min. Abt. 100 spec. 5—7 mm. — **St. 107.** ibid. 300 m.w., 9^{05} am., 30 min. 14 spec. 4—7 mm. — **St. 107.** ibid. 2000 m.w., 7^{30} am., 60 min. 2 spec. 7—8 mm. — **St. 108.** 65 m.w., 11^{15} pm., 30 min. 2 spec. 5—7 mm. — **St. 108.** ibid. 300 m.w., 10^{30} pm., 30 min. Abt. 50 spec. 4—7 mm. — **St. 108.** ibid. 2000 m.w., 0^{40} am., 60 min. 9 spec. 7—8 mm. — **St. 113.** 300 m.w., 3^{25} am., 30 min. Abt. 30 spec. 4—8 mm. — **St. 115.** 300 m.w., 11^{20} pm., 30 min. 5 spec. 7 mm. — **St. 115.** ibid. 2000 m.w., 0^{30} am., 60 min. 1 spec. 6 mm. — **St. 118.** 65 m.w., 11^{35} pm., 30 min. 2 spec. abt. 7 mm. — **St. 276** ("Pangan"). > 3000 m. 36°30′ N, 19°20′ E. 4—4—1911. — 132 m.w., 11^{55} pm., 35 min. 4 spec. 5—7mm. — **St. 278.** 230 m. 38°11.5′ N, 15°37.5′ E. 22-2-1911. 15 m.w., 3^{20} pm., 120 min. Abt. 50 spec. 4—7 mm. — **St. 279.** 350 m. (= St. 279). 23-2-1911. 30 m.w., 9^{30} pm., 150 min. Abt. 30 spec. 5—7 mm. — **St. 280.** 230 m. (= St. 278). 25-2-1911. 15 m.w., 7^{20} pm., 120 min. Abt. 30 spec. 5—7 mm. — **St. 281.** 200 m. 38°13′ N, 15°36.5′ E. 1-3-1911. 10 m.w., 5^{55} pm., 60 min. 6 spec. 3—7 mm. — **St. 281.** ibid. 30 m.w., 4^{45} pm., 60 min. 18 spec. 3—6 mm. — **St. 281.** ibid. 40 m.w., 7^{10} pm., 60 min. Abt. 30 spec. 6—7 mm. — **St. 281.** ibid. 40 m.w., 8^{50} pm., 30 min. Abt. 30 spec. 4—7 mm. — **St. 282.** 200 m. 38°12′ N, 15°37′ E. 9-3-1911. 40 m.w., 3^{30} am., 90 min. Abt. 40 spec. 4—7 mm. — **St. 282.** ibid. 40 m.w., 7^{00} pm., 90 min. Abt. 50 spec. 4—7 mm. — **St. 282.** ibid. 40 m.w., 8^{45} pm., 90 min. Abt. 60 spec. 5—7 mm. — **St. 282.** ibid. 40 m.w., 10^{30} pm., 90 min. Abt. 60 spec. 5—7 mm. — **St. 283.** 200 m. (= St. 282).

[1] I have not had access to this paper.

12-3-1911. 40 m.w., 9^{30} pm., 180 min. Abt. 60 spec. 5—7 mm. — **St. 698** ("Pangan"). > 200 m. 37°20′ N, 9°25′ E. 25-2-1913. 5^{00} am. 5 spec. 4—8 mm. — **St. 729** ("Nordboen"). 200 m. 41°00′ N, 17°44′ E. 14-4-1913. 4 spec. 4—8 mm. — **St. 730** ("Nordboen"). 2000 m. 38°36′ N, 13°37′ E. 16-4-1913. 2^{00} pm. 5 spec. 6—7 mm.

Atlantic.

St. 72. 1020 m. 57°52′ N, 9°53′ W, 8-6-1905. 1500 m.w. 10 spec. 6—8 mm. — **St. 376** ("Florida"). > 3500 m. 34°41′ N, 16°14′ W. 22-7-1911. 15 m.w., 8^{45} pm., 30 min. Abt. 500 spec. (10 ccm.) 4—9 mm. — **St. 377** ("Florida"). > 4300 m. 31°23′ N 18°08′ W. 23-7-1911. 15 m.w., 8^{05} pm., 30 min. Abt. 2000 spec. (35 ccm.) 4—9 mm. — **St. 382** ("Florida"). > 1100 m. 34°31′ N, 16°24′ W. 23-10-1911. 22 m.w., 6^{35} pm., 30 min. 2 spec. 7—8 mm. — **St. 399** ("Ingolf"). > 2600 m. 34°23′ N, 15°31′ W. 26-10-1911. 56 m.w., 9^{40} pm., 30 min. 4 spec. 5 mm.

The "Thor" material contains numerous larvæ of a type which are at any rate identical with the larvæ whose telson is shown by Claus l. c. in fig. 6. It is possibly also the same larva of which Claus has shown some appendages in figs. 1, 3—5. But it is hardly identical with Claus' fig. 2, for if this figure be correct, then the caudal spines, especially on 3.—6. caudal segment, are longer than those on the specimen of the corresponding stage in the "Thor" material, and the telson also seems too markedly bifid. Another circumstance which suggests that the larvæ mentioned by Claus are not all of the same species, is the maximal size he himself indicates: 11 mm., as the largest specimens from the "Thor" are only 8 (9) mm., though they are at exactly the same stage of development as the largest mentioned by Claus (we have, however, in our Museum a very few specimens of the same species of 10—12 mm.).

That the larva mentioned by Claus really comprises at least two species is rendered more probable by the fact that I have recognised what I believe to be specimens of both among the material at our Museum. Of the large form with deeply cleft telson and relatively long spines on the dorsal side of the tail, there are in our Museum abt. 10 specimens from 34°50′ S, 41°30′ E, Andrea leg. 1864, length abt. 10—12 mm. The pleopoda are bifid and large, the telson cleft for $^1/_3$-$^1/_4$ of its total length; in the cleft there are four pairs of long ciliate setæ, and on the outside 2 pairs of shorter spines, besides one pair of spines midway along the exterior margin of the telson.

All the remaining old material in our Museum, as also the entire material from the "Thor", plainly comprises only the smaller species, which has shorter spines on the dorsal side of the tail, with telson in the older stages very slightly cleft.

This smaller species, of which we have specimens of (3.5) 4—8 (9) mm., may, in the various stages (all mysis stages) be characterised as follows:

Total length 3.5 mm. (only very few specimens). P. 4—5 not indicated. Forward-pointing hook on either side of 1—3 abdominal segments, largest on the two first. Spines on dorsal side of 3—5 caudal segments rather long, almost as long as the segments. The telson has midway on either side a small spine, and is cleft for abt. $^1/_3$rd of its total length (excluding apical spines). Each branch of the telson has six spines at the point, the apical spine being much longer and heavier

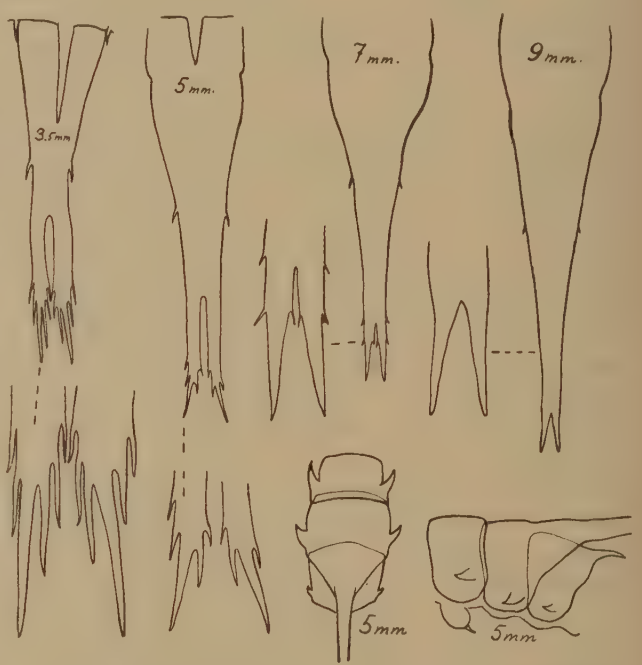

Fig. 7. Euphema (armata?), the larva of ? Gennadas elegans. Telson of specimens 3.5—9 mm. Below to the right 1.—3. abdominal segment of a specimen 5 mm. long, dorsal and side view.

than the others. This stage answers to Claus, Pl. 3 fig. 6. —

Total length 5 mm. P. 4 in length as the other pereiopoda, P. 5 length as peduncle in p. 4. Plp. 1, which in the foregoing stage was shaped like a small sphere, has not assumed an ovular shape. Still no trace of plp. 2—5. Spine on dorsal side of 3—5 caudal segment now only half the length of the segments; spine on 6. joint in length as the foregoing ones. Cleft of telson only abt. $^1/_4$ total length (excl. apical spine). On the inner side of either branch of the telson there are only two spines inside the apical spine (formerly 3). There may often be one spine more on the one side than on the other.

Total length 6 mm. P. 5 half as long as p. 4; plp. 2—5 indicated as small processes. Spine on side of 3. caudal segment has disappeared. Telson has same no. of teeth as in the foregoing stage, but the cleft runs only $^1/_9$th of the way in. —

Total length 7 mm. P. 1—3 with indication of chela. P. 5 not much shorter than p. 4, but endopodite in p. 4 somewhat shorter than in p. 1—3. Plp. 2—5 bifid, but very small. Spines on dorsal side of abdomen shorter than before. Telson approximately as in foregoing stage, but the cleft still smaller, only abt. $^1/_{16}$ total length of telson (excl. apical spine); only one pair of spines on inner side of cleft. Apical spines much heavier than the other spines; or rather, these spines are considerably weaker than in the younger stages. —

Total length 9 mm. Same stage (but hardly same species) as CLAUS' Pl. 3 fig. 2, but differs especially in having the teeth on the back much shorter, and much smaller cleft in the telson. CLAUS' specimen is 11 mm.; the largest of the "Thor" — specimens are 9 mm. The spines on the side of 1—2 caudal segments are not indicated in CLAUS' figure. — P. 1—3 with distinct chela, p. 4—5 almost equal in length to p. 1—3. Plp. 2—5 large and bifid. Cleft of telson amounts now to abt. $^1/_{12}$ of telson's total length, the apical spine now running into one with the remaining part of the sides of the cleft; the other spines have altogether disappeared with the exception of the one situate about midway on either side of the telson.

The few specimens of the same species which are larger, (10—12 mm.) and are found in the old and hitherto undetermined material of our Museum, do not differ in any respect from the larges specimens of the "Thor" collection.

Colour. The labels on some of the specimens in our Museum, from 30° S, 96° E and 29°10′ S, 96°20′ E, read "blue when alive".

For the determination see supra p. 20

Synonymy. It is doubtful whether the above list of synonyms (which, save for the reference to *Gennadas* (*Amalopenæus*) *elegans*, is taken from ORTMANN 1893) comprises a single species or several. It is likely that the larva mentioned and described by BATE is identical with the one from the "Thor", as the spines on the dorsal side are not particularly long. More doubtful is the case of the larva described by MILNE-EDWARDS; ORTMANN gives no description at all.

The material includes abt. 3200 specimens from 29 stations, 42 hauls.

A. Mediterranean.

	Stations	Hauls	Specimens
Dec. 1908	1	1	3
Jan. 1909	1	1	1
Feb. —	1	1	65
June 1910	8	15	181
Feb. 1911	3	3	110
March —	3	9	284
April —	1	1	4
Feb. 1913	1	1	5
April —	2	2	9
total...	24	37	662

The larvæ were thus taken in Dec., Jan.—Apl., and June; they were not found in the hottest summer months. The size affords no aid to determining any particular time for hatching out.

Depths in m.	No. of stations
0—500	11
> 500—1000	2
> 1000—2000	2
> 2000—3000	7
> 3000	2
total...	24

Of the 24 stations where the larva was found, 5 are in the eastern basin, but only in its western part (including the Adriatic), the remainder in the western basin (see chart 2).

Nearly half the stations where the larva was found had a depth of less than 500 m., one indeed only 20 m., which undoubtedly agrees with the fact that the larvæ are found comparatively near the surface.

Vertical occurrence. In winter (19 hauls in all) practically all the specimens were taken with 10—40 m.w or 65 at the outside, and there is hardly any difference between day and night. In summer, on the other hand,

Chart 2. Euphema (ar mata?).
The stations in the Atlantic lie outside the chart.

the depth seems to be greater, night at least 40 m.w., especially 300 m.w.; the three day hauls are not enough to judge from.

B. Atlantic.

We have about 2500 specimens from 5 stations, 5 hauls. One station is situate west of Ireland, the other SW of the Bay of Cadiz. Though the material comprises a very great number of specimens, the hauls are still too few to judge by, but there seems to be no difference compared with conditions in the Mediterranean, save for the fact that nearly all the specimens were taken in the hottest period of summer (July).

Distribution.

1. Mediterranean, see above. — "Mediterranean" (Claus).

2. Atlantic. On the "Thor" see above. — Our Zoological Museum possesses specimens from the following localities: 37°30′ N, 52°13′ W, Andrea 1867, 1 spec.; 40°13′ N, 13°35′ W, Andrea 1862, 2 spec.; 33°6′ N, 25°30′ W, Andrea 1862, 1 spec.; 33° N, 47° W, "Galatea"-Exped., 2 spec.; 30° N, 19° W, Hygom 1853, 1 spec.; 27°11′ N, 88°52′ W, to 29°39′ N, 88°45′ W, "Galatea"-Exped., 1 spec.; 23°2$^3/_4$′ N, 31°48′ W, Mathiesen 1848, 1 spec.; 22° N, 20′ W, Hygom, 1 spec.; 29°0′ S, 37°23′ W, Warming 1866, 1 spec.; 13° N, 27° W, Krøyer, abt. 35 spec.; 31°16′ S, 24°20′ W, Andrea 1869, 1 spec. —

Ortmann mentions the species from the following localities: Sargasso Sea 10 st. 31.6° N, 60.2° W, to 19.9° N, 27.2° W; N. Equatorial Current 3 st. 18.9° N, 26.4° W, to 10.2° N, 22.2° W, and 12° N, 40.3° W; S. Equatorial Current 5 st. 0.1° N, 15.2° W, to 5.1° S, 14.1° W, 6.9° S, 23.4° W, 5.7° S, 26.5° W, 3 st. 4.1° S, 14.6° W, to 7.5° S, 20.3° W, 3.8° S, 32.6° W, and 2.4° S, 36.4° W; Guinea Current 5.9° N, 20.3° W, and 9.4° N, 41.9° W. When the depth is noted, it is surf. to 0—400 m.

"Atlantic" (Claus). — 5°28′ N, 14°38′ W (Bate). — "Southern Atlantic" (Milne-Edwards).

3. Indic. 25° S, 61° E, Strandgaard, 1 spec.; 27°—29° S, 62$^1/_2$°—65$^1/_2$° E, Caspersen 1869, 4 spec.; 33°30′ S, 89°30′ E, Andrea 1870, 1 spec.; 30° S, 96° E, Andrea 1870, 1 spec.; 29°40′ S, 96°20′ E, Andrea 1870, 3 spec.; 27°30′ S, 98°—99°10′ E, Andrea 1870, 6 spec. (Spec. in our Zool. Museum).

4. Pacific. Hongkong, Dr. Mayer, 2 spec. (in our Zool. Mus.).

Penæid-larva No. 2.

Euphema (polyacantha Ortm.?) (Fig. 8), Larva of Gennadas sp.? (see above, p. 21).

?*Aristeus* (?), *Megalopa*, Bate 1888, p. 241, Pl. 47 fig. 1.
?*Euphema polyacantha* Ortmann 1894, p. 77.
?*Penæus? sp.*, *Aristeus* Williamson 1915, p. 340, fig. 7.

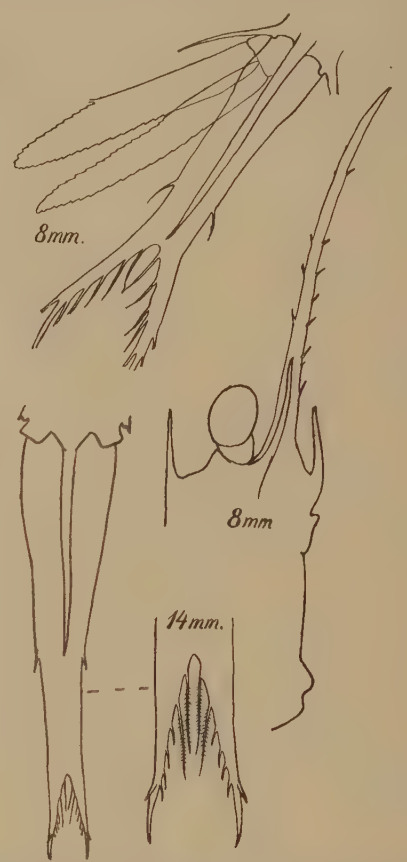

Fig. 8. Euphema (polyacantha?). Carapace and caudal fan of a specimen 8 mm. long, and telson of a specimen 14 mm. long.

St. 66. 735 m. 36°16′ N, 6°52′ W. 25-2-1909. 1200 m.w., 8^{30} am., 120 min. 1 spec. — **St. 69.** >3500 m. 36°13′ N, 9°48′ W. 28-2-1909. 65 m.w., 10^{45} pm., 30 min. 2 spec. — **St. 69.** ibid. 300 m.w., 11^{40} pm., 30 min. 5 spec.

These larvæ have been referred, albeit with some doubt, to *Euphema polyacantha*. They agree with Ortmann's description in having a long spine and a process at root of the rostrum (Bate does not mention the long spine), but differ both from Bate and Ortmann in having a pair of long, outward pointing spines laterally on the 1.—3. abdominal segments of the same shape, but even larger than shown in *E.* (*armata?* fig. 7) and also in

having long spines on the hindmost lateral corners of the 4—6. abdominal segments (these spines have, however, mostly disappeared in the largest specimens); besides lacking the spine which BATE places midway on the lower margin of the 6. abdominal segment, and by having a process midway above the posterior margin of the carapace. All the spines mentioned, (except the lateral spines on the 6. abdominal segment) are found both in large and small specimens, but are relatively larger in the small ones. The same applies to the rostrum (which in the smallest individuals is abt. $1^1/_2$ times as long as the carapace ex. rostrum) not, however, to the spines on the dorsal side of the tail, which are relatively of equal length in all the present specimens.

In the smallest specimens (8 mm.) there is an indication of chela in p. 1—p. 3. P. 4—p. 5 are somewhat smaller than p. 3. Plp. 1 is swollen out as in *E. armata*, plp. 2—5 are small, hardly bifid warts. Telson cleft for abt. $^1/_3$ its total length (ex. apical spines); in the cleft are 5 or 6 pairs of spines, and 1 or 2 pairs outside, besides a pair of lateral spines a little proximal to the inner end of the cleft. (The point of the telson is somewhat damaged in all specimens, so that the no: of spines cannot be stated exactly).

The largest specimen (14 mm.) is at the same stage of development as regards its appendages as BATE Pl. 47 fig. 1. Cleft of telson only abt. $^1/_5$ of its total length (incl. apical spines). In the cleft are 6 pairs of spines, of which the two proximal pairs are pennate setæ and much longer than the others.

Distribution. Atlantic, between Cape Verde and Azores, April 29., 1876, 1 spec. (BATE). — Guinea Current 9.4° N, 41.9° W, 0—400 m., 1 spec. (ORTMANN).

Penæid-larva No. 3 (Fig. 9).

(Larva of Penæus caramote? or Aristeus antennatus, see above p. 21.)

Mediterranean.

St. 189. 1683 m. 37°44′ N, 15°55′ E. 19-8-1910. 1000 m.w., 9^{30} am., 30 min. 1 spec. abt. 10 mm. — **St. 339** ("Pangan"). > 2000 m. 40°30′ N, 3°10′ E. 20-8-1911. 28 m.w., 3^{00} am., 30 min. 4 spec. abt. 7 mm.

This larva is characterised by its rostrum, which has on the upper margin 3—8 teeth, according to age, but none on the under side, and by its tail, which has no dorsal spines except a very small one on the 6th caudal segment, apart from the telson, which is truncate.

The rostrum (reckoned from the ocular sinus) is $^1/_2$—$^2/_3$ as long as the carapace ex. rostrum; it is nearly straight, compressed and powerful, and has on the upper margin 3—8 teeth, according to age, none on the under margin. There is a supra-ocular tooth, otherwise no teeth on the fore margin of the carapace. Tail very powerful, 6. joint much compressed, equal in length to the four preceding ones together. Tail altogether without dorsal spines, save for a single short one on the posterior margin of the 6. segment. Telson almost of uniform breadth throughout, and cut off almost straight at the point, with six pairs of short spines on the posterior margin

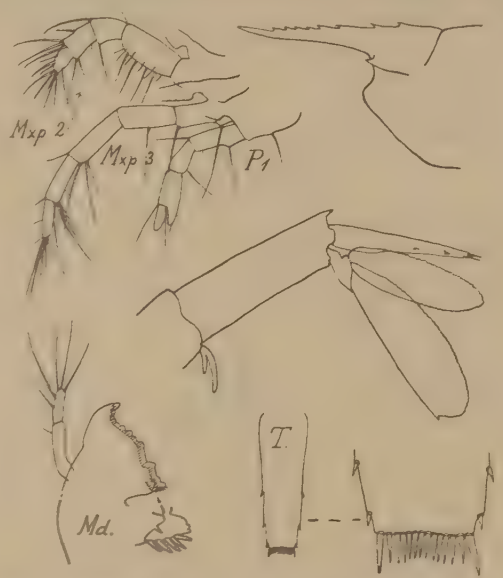

Fig. 9. Penæid-larva No. 3. Rostrum, mandible, 2.—3. maxilliped, 1. pereiopod, caudal fan, and telson.

and one larger one at each corner; 3 spines on either side. Urop. large and powerful, outer ramus abt. $1^1/_2$ times as long as the telson.

Eyes very large. As regards the oral parts, (which have been dissected out from the large specimen) there is nothing particular to remark. Md. has a two-jointed palpa and abt. 6 spines in the proximal portion of the masticatory part, mx. 1—2 and mxp. 1 correspond fairly accurately to Claus 1876 Pl. 3 fig. 3—5. Even the smaller specimens have a chela on p. 1—3. P. 4—5 developed in all specimens, but even in the largest specimen somewhat smaller than p. 1—3. In the smallest specimen, plp. are only small protuberances; in the largest one they are bifid, but not yet very large. In none of the specimens had plp. 1 the swollen shape found in *Euphema* (see CLAUS 1876, Pl. 3, fig. 1—2).

Distribution. The Zoological Museum has a spec-

imen at the same stage as the largest from the "Thor" recorded as from "Atlantic 33°—36° N, PETERSEN ded., 1857" and measuring abt. 11 mm.

Penæid-larva No. 4 (Fig. 10).
(Larva of Funchalia Woodwardii?, see above p. 21).

Mediterranean.

St. 143. 1842 m. 35°18′ N, 16°25′ E. 23-7-1910. 300 m.w., 0^{30} am., 30 min. 1 spec. 12 mm. — **St. 175.** 1103 m. 40°48′ N, 27°59′ E. 11-8-1910. 400 m.w., 11^{20} pm., 30 min. 1 spec. abt. 16 mm. (rostrum lost). — **St. 175.** ibid. 1200 m.w., 0^{25} am., 30 min. 1 spec. 7.5 mm.

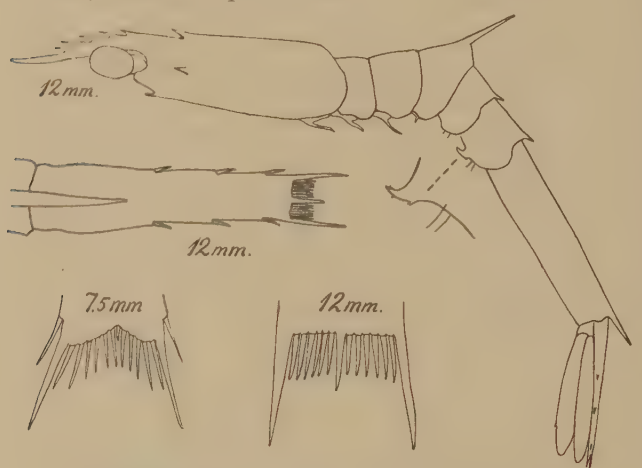

Fig. 10. Penæid-larva No. 4. A larva of 12 mm. length and its telson; apex of telson of a larva 7.5 mm. long.

This larva is characterised especially by the dentate upper part of the rostrum, by the spines on dorsal side of 3—6. abdominal segments (largest on the third), by the hook formation in the inferior margin of the epimeral part of 5. abdominal segment, and by the long, soft, filiform process midway below the posterior part of the pereion and the two anterior abdominal segments. The specimen of 12 mm. is the best preserved, and the following description is therefore taken from this; the other specimens are later compared therewith.

Rostrum somewhat over half the length of the carapace ex. rostrum, rather powerful, with 5 teeth on the upper side, besides one a little in rear of the base. No teeth on the lower margin. No supra-ocular tooth; there is, however, a tooth on the lower anterior corner of the carapace, and there is an hepatic spine. The tail has a rather long spine on the dorsal side (not posterior margin) of 3. caudal segment, and on the posterior margin of 6. segment, and one quite short one on the 4—5. segment. Midway along the ventral side of the hinder part of the pereion and on the 1.—2. caudal segment there is a fairly large, but soft, filiform process; a very small one also on the 3. segment. The inferior lateral margin of the 5. caudal segment forms a hook. Telson of almost equal breadth throughout, cut off straight at the rear, and with three pairs of lateral spines. The posterior margin has at each corner, and also in the middle, a fairly large spine, not articulate; between the middle spine and each of those at the corners there are six shorter, articulate spines.

Distinct chela on p. 1—p. 3; p. 4—p. 5 in length as p. 3. Pleopoda bifid, inner ramus however only quite short; some few natatory setæ present. Plp. 1 of same shape as the rest, not swollen.

The small specimen, (7.5 mm.) differs in having only 3 + 1 spines above the rostrum; behind the hindmost there is a wart in on the carapace. In p. 1—p. 3 there are distinct though very small chelæ, but p. 4—p. 5 are of same size as p. 3. Pleopoda very small, hardly bifid. Telson as in the older specimen save in having the posterior margin slightly notched (see fig.); no large median spine, but six pairs of articulated spines, one of the midmost being much smaller than the rest, this, however, seems to be accidental.

The largest specimen (16 mm.) has lost almost the whole of the rostrum, so the number of teeth cannot be given. Chelæ so far developed as to have apparently a true movable digit. Pleopoda have natatory setæ on both rami. Telson with 5 pairs of spines between the corner and median spines.

Caridea.

Fam. Pasiphæidæ Dana.

Pasiphæidæ Dana 1852, p. 532, 536.
* — Stebbing, Edinburgh 1914, p. 293 (lit. and key to the genera).
— Pesta 1918, p. 62 (lit.).
— de Man 1920, p. 1 (list of all genera and species).

The family of the *Pasiphæidæ* is represented in the "Thor" area (S. of abt. 50° N) by two genera, the *Pasiphaë* and the *Parapasiphaë*, with 3 (4) and 2 species respectively. To these must be added 2 species, *Dantecia caudani* CAULLERY (CAULLERY 1896, p. 372, pl. 14, figs. 1—11) and *Psathyrocaris fragilis* WOOD-MASON var.

atlantica Caullery (ibid. p. 374, Pl. 14, figs. 12—15) one specimen of each being taken in the Bay of Biscay, at 1710 and 800 m. respectively and mentioned by Caullery l. c. but hardly met with again since then.

The genus *Parapasiphaë* has, besides the well-known species *P. sulcatifrons*, mentioned below, also a species *P. Grimaldi* Coutière (Coutière 1911, p. 157) of which two specimens were taken off the coast of Portugal at 36°—45° N, 11° W; the specific diagnosis is extremely brief, and runs as follows: "*P. G.* reproduit sauf des différences tres légères, l'espèce de l'Océan Indien, *P. latirostris* Alcock. Mais elle ne possède pas de palpe mandibulaire, annulant ainsi la valeur d'un caractère considéré comme fondamental entre les genres *Pasiphaë* et *Parapasiphaë*."

According to Carus (1885 p. 482) a mysterious species is described from Naples, *Pasiphaë neapolitana* Hope, Ann. Accad. Aspir. Nat. vol. 4, p. 131. It is "affinis *P. Savignyi*" (= *P. sivado*) but can hardly be determined from the description. As, however, we know with certainty from the Mediterranean only *Pasiphaë multidentata* and *P. sivado*, it is probably identical with one of these (here disregarding Pesta's highly improbable record of *P. principalis* from the Adriatic (Pesta 1918, p. 67); see under *P. multidentata* below).

As above mentioned, there are hardly more than 2 species known from the Mediterranean (almost exclusively the western basin) to wit, *P. multidentata* and *P. sivado* (but no species of *Parapasiphaë*); both these two species were taken by the "Thor" at a considerable number of places, and are found at night almost exclusively in the upper water layers, 10—300 m.w., though by day they live considerably deeper down. They are glassy clear, almost colourless, and rather firm-skinned. Both are likewise found in the northern Atlantic.

Besides these two, we also find in the "Thor" area of the North Atlantic, the two above-mentioned species of *Parapasiphaë* and *Pasiphaë principalis* (but hardly *P. tarda*) but these keep, even at night, rather far down (*Parap. sulcatifrons* was at any rate not taken by the "Thor" higher up than with 1500 m.w.) and they are red and rather soft (except *P. tarda* in specimens of more than abt. 80—100 mm.).

The development is not known, but as *Parap. sulcatifrons* has very large eggs, it has doubtless a very abbreviated larval development.

Genus Pasiphaë (Savigny) Krøyer.

Pasiphæa Savigny, Mém. sur les Animaux sans vertèbres 1816, p. 50, note.
Pasiphaë Kröyer 1845, p. 453.
— Bate 1888, p. 863.
Phyë Wood Mason 1893, p. 164.
Pasiphæa Sund 1912.
— Pesta 1918, p. 63.
— de Man 1920, p. 1 (list of all species), 5.

Save for the easily recognisable *P. sivado*, the other North-Atlantic species have been the subject of much misunderstanding, being alternately conjoined or separated into several species.

Briefly, the facts are as follows: The American species *P. princeps* has been found in the Northern Pacific and at Equador (see Rathbun 1904, p. 23—24) and in the northern Atlantic only off the American coast: 3°9′ N, 82°8′ W, 1132 fms. 1 spec. (Faxon 1895) and 32°27½′ N, 77°20½′ W, (Rathbun 1904, p. 24) to 37°59½—39°39¾′ N, 71°35¼′—73°48½′ W, 444—693 fms. 5 spec. (Smith 1882, 1885 [1886]). For the difference compared with *P. principalis* see Sund 1912, p. 11—12.

The remaining species, on the other hand, which were originally established under several different names comprising several synonyms, were later united in a single species "*P. tarda* Kr." until Kemp, 1910 divided this into two; viz. "*P. tarda* Kr." (= *P. multidentata* Esmark) and "*P. princeps* Smith" (= *P. principalis* Sund + ?*P. tarda* Kr.). In my work on the Decapods of the "Tjalfe" 1912 I furnished reasons for uniting the mentioned species in one. True, this result was not correct, but it is explained by the fact that *P. multidentata* and *P. tarda*, in contrast to *P. principalis*, have the same shaped carina on the 6. caudal segment, so that I did not distinguish between even the largest specimens of one and the other; and *P. tarda* and *P. principalis*, as is also evident from Sund's description, are certainly not to be distinguished one from another in specimens less than abt. 60 mm. (according to may own material, this limit should indeed be raised to abt. 75 mm.).

Shortly after the appearance of my work, Sund (Sund 1912) explained that there were 5 species in the North Atlantic, viz. besides *P. sivado* and *P. princeps* Smith, also *P. multidentata* Esmark, *P. tarda* Kr. and *P. principalis* Sund. Sund gives (l. c. p. 3—4) a list of determinations of the European species; for the difference between *P. principalis* and the species *P. princeps*, which latter is probably exclusively American, see l. c. p. 11—12.

As the "Thor" has yielded a not inconsiderable quantity of material (chiefly, however, belonging to a

single one of the species here in question) I have, in addition to going through the "Thor" material, also carried out a new revision of all the older material in our Museum, both from the Northern Atlantic and from Denmark (mentioned by H. J. Hansen 1908, p. 78; K. Stephensen 1910, p. 289 and 1912 ("Tjalfe") p. 65). As the starting point of this revision I have taken a number of specimens determined by O. Sund during a stay in Copenhagen in July 1912. Unfortunately, I was away in Greenland at the time, so that there was no opportunity of discussing the matter verbally with him.

And here I may state at once that this fresh revision on the whole confirms the main result of Sund's examination, viz. that there are in Europe three species besides *P. sivado*; my material, however, does not bear out all the details quoted by him, and as will be seen from what now follows, his list of determinations for the species (l. c. p. 3—4) can only be used for larger specimens and is by no means applicable to specimens of all sizes, the specific characters being only developed with increasing age.

P. multidentata. The best specific character the 7—12 spines on the base of P. 2 can only be used for determining large specimens, over abt. 50 mm., smaller individuals have only a smaller number of spines, or none at all, and can thus in this respect be confused with *P. tarda* and *P. principalis*. Specimens with a total length of less than 50 mm. or thereabouts can, according to Sund's text, (p. 11) and figures (Sund, fig. 5—7; from the text, the left column in the three figures should be *P. multidentata*, the right *P. principalis*) be distinguished from the two other European species, even when no more than 14—20 mm. (carapace 4—6 mm.). That the species is easily distinguishable at a relatively small size is undoubtedly partly due to the fact that the species is altogether smaller in size than the two others; ♀ with ova may be met with right down to 57—60 mm. (carapace 17—18 mm.).

According to the material I have myself examined, *P. multidentata* can not always be distinguished with certainty from the other species before reaching a total length of abt. 30—35 mm.; in smaller specimens (20—30 mm.) the antennal plate may be shaped as in Sund's fig. of this species, while the outer ramus in the urop. is shaped as in the other species, or both may have an intermediate form, not coinciding exactly with either of the species. The rostrum, again is not altogether serviceable as a means of determination with such small individuals.

When the species has attained a size of abt. 50 mm., it has — a point not mentioned in the literature — the carina of the 6. abdominal segment shaped as in *P. tarda* Kr. (K. Stephensen: "Tjalfe" 1912, fig. 1 p. 68). The fact that this keel is of the same shape in the two mentioned species was the principal reason for my — incorrectly — uniting them as one species in my work on the Malacostraca of the "Tjalfe".

Chart 3. Pasiphaë. • P. multidentata. + P. principalis.

P. principalis and P. tarda are far more difficult to distinguish one from the other, save in the case of large specimens. Sund gives some lists of localities (Sund 1912, p. 13, 16) with measurements of the specimens there found. We find here, it is true, specimens with a carapace no larger than 5 or 11 mm. length (*P. principalis*); but he himself states (p. 12) that he would not venture to determine with any certainty specimens having the carapace less than 20 mm., answering to a total length of abt. 60 mm. Where he does give a determination of smaller individuals, it is only such as were taken together with larger specimens which were determinable themselves with certainty. (Sund, p. 12, 17).

From the material at my disposal it appears that in seeking to distinguish between these two species we have hardly more than two good characters

(and even these can only be used with specimens over 60—75 mm.) viz. the rostrum (Sund fig. 9) and the keel on the 6. abdominal segment (K. Stephensen "Tjalfe" 1912 fig. 1).

1. PASIPHAË MULTIDENTATA Esmark

(Chart 3, partim).

Pasiphæa multidentata Sund 1912, p. 3, 4—5 (lit. and syn.), fig. 1 (distribution), figs. 2—4, p. 6—11, figs. 5—7 (the left series of detail figures).

Pasiphaë tarda Kemp 1910, p. 39—43, Pl. 4 fig. 8—11.

? — (*Phye*) *sicula* Riggio 1895—96, p. 7—13, Pl. 1 fig. 2.

?*Pasiphæa principalis* Pesta 1918, p. 67, fig. 21.

Mediterranean.

St. 14. 1125 m. 41°24′ N, 17°45′ E. 21-12-1908. 300 m.w., 6^{30} am., 60 min. 1 ♀ 49 mm. — **St. 14.** ibid. 1000 m.w., 8^{20} am., 90 min. 2 spec.: 1 spec. 34 mm., 1 ♀ 61 mm. — **St. 34.** > 2000 m. 43°27′ N, 8°16′ E. 23-1-1909. 200 m.w., 6^{35} am., 30 min. 1 jun. 11 mm. — **St. 35.** > 2000 m. 43°36′ N, 7°36′ E. 29-1-1909. 200 m.w., 6^{40} pm., 60 min. 1 ♀ 60 mm. — **St. 36.** > 2000 m. 42°49′ N, 6°54′ E. 30-1-1909. 300 m.w., 6^{50} am., 60 min. 2 spec. 30—43 mm. — **St. 53.** > 2000 m. 36°13′ N, 1°28′ W. 18-2-1909. 2600 m.w., 5^{15} pm., 90 min. 2 spec. 18 mm. — **St. 107.** > 2000 m. 36°13′ N, 1°28′ W. 25-6-1910. 2000 m.w., 7^{30} am., 60 min. 5 spec.: 11.5, 20, 23, 39, 46 mm. — **St. 108.** > 2435 m. 36°03′ N, 0°27′ W. 26-6-1910. 2000 m.w., 0^{40} am., 60 min. 10 spec.: 5 spec. 16—21 mm., 5 spec. 31—41 mm. — **St. 112.** 2700 m. 36°56′ N, 2°15′ E. 27-6-1910. 300 m.w., 0^{15} am., 30 min. 2 spec. 26—34 mm. — **St. 115.** 2800 m. 38°17′ N, 4°11′ E. 28-6-1910. 300 m.w., 11^{20} pm., 30 min. 1 spec. 36 mm. — **St. 115.** ibid. 2000 m.w., 0^{30} am., 60 min. 1 spec. 32 mm. — **St. 116.** 2860 m. 39°27′ N, 5°26′ E. 30-6-1910. 300 m.w., 1^{40} am., 30 min. 4 spec. 24—32 mm. — **St. 120.** 2700 m. 42°31′ N, 7°41′ E. 1-7-1910. 300 m.w., 8^{50} pm., 30 min. 3 spec.: 30, 34, 44 mm. — **St. 122.** > 1500 m. 43°50′ N, 8°34′ E. 2-7-1910. 1200 m.w., 5^{30} pm., 60 min. 4 spec.: 3 spec. 22, 27, 39 mm.; 1 ♀ 107 mm. (Carapace 33 mm.). — **St. 123.** > 600 m. 44°14′ N, 8°55′ E. 3-7-1910. 300 m.w., 0^{05} am, 30 min. 1 spec. 39 min. — **St. 125.** 1082 m. 43°57′ N, 9°13′ E. 9-7-1910. 300 m.w., 9^{45} pm., 30 min. 2 spec. 43—46 mm. — **St. 129.** 3420 m. 40°05′ N, 11°31′ E. 12-7-1910. 3500 m.w., 3^{00} pm., 120 min. 1 spec. 29 mm. — **St. 160.** 2980 m. 35°59′ N, 28°14′ E. 1-8-1910. 4000 m.w., 3^{30} pm., 60 min. 1 spec. 31 mm. — **St. 187.** > 2500 m. 37°54′ N, 18°02′ E. 18-8-1910. 1000 m.w., 6^{40} pm., 30 min. 1 spec. 34 mm. — **St. 206.** 2782 m. 39°32′ N, 5°15′ E. 28-8-1910. 1000 m.w., 1^{40} am, 45 min. 3 spec.: 32, 46, 48 mm. — **St. 206.** ibid. 2000 m.w., 3^{05} am, 45 min. 1 spec. 47 mm. — **St. 209.** > 2000 m. 40°34′ N, 3°03′ E. 29-8-1910. 2000 m.w., 7^{25} am, 45 min. 1 spec. 30 mm.

Atlantic.

St. 3. 280 m. 58°52′ N, 4°18′ E. 30-4-1903. 3 spec. 34, 43, 57 mm. — **St. 152.** 1240 m. 60°00′ N, 28°10′ W. 19-6-1904. 1000 m.w. 1 spec. 32 mm. — **St. 285.** Depth?. 62°49′ N 18°46′ W. 1-9-1904. 100 m.w. 1 ♀ 76 mm. — **St. 61.** 963 m. 61°11′ N, 11°00′ W. 28-5-1904. 900 m.w., 60 min. 1 ♀ with ova 102 mm. — **St. 179.** 4000 m. 47°20′ N, 12°25′ W. 3-9-1906. 1800 m.w., 3^{40} am, 120 min. 1 spec. 41 mm. — **St. 76.** 1800 m. 47°01′ N, 5°48′ W. 10-3-1909. 1600 m.w., 2^{40} pm., 60 min. 1 spec. 27 mm. — **St. 232.** 3700 m. 36°28′ N, 9°06′ W. 9-9-1910. 1000 m.w., 10^{35} pm., 30 min. 1 spec. 37 mm.

On the determination of the species, etc., see above p. 28. The material comprises 59 specimens (52 spec. 11—48 mm., 7 ♀ 49—107 mm.) from 26 stations, 29 hauls; almost the whole of the material was taken in the Mediterranean.

A. Mediterranean.

The material comprises 50 specimens, (46 of 11—48 mm., 4 ♀ 49—107 mm.) from 19 stations, 22 hauls, taken both winter and summer.

Depths of the sea and occurrence. (Chart 3). The depth to bottom was over 600—3420 m. especially over 2000—3000 m. The stations lie distributed throughout the whole of the Mediterranean; only 3 however, lie in the eastern basin; 1 in the southern Adriatic, 1 between Sicily and Greece, and one at the entrance to the Ægean.

Depths in m.	No. of stations
500—1000	1
> 1000—2000	3
> 2000—3000	14
> 3000	1

As all the specimens not altogether small (over abt. 30 mm.) and also the great majority of the still smaller ones could be referred with certainty to this species, there can be no doubt but that the remaining very small specimens belong to the same. As, therefore, the whole of the "Thor" material from the Mediterranean does not include a single specimen which can be ascribed to any other species, it is extremely probable that the specimens previously recorded from the Mediterranean (Lo Bianco 1903, and Pesta 1916) as *P. tarda* are in reality specimens of *P. multidentata*. Riggio has (l. c. 1895—96) described a new species, *P. sicula*, from a single large ♀, (124 mm., carapace 46.5 mm.) from Augusta, between Catania and Sicarusa. This specimen also (the "species" has never been met with since) would seem to be referable to the same species. In all probability, then, there should be in the Mediterranean, apart from the easily distinguishable *P. sivado* — no other species than *P. multidentata*.

Pesta (1918 p. 67) mentions some specimens from the Adriatic as belonging to "*P. principalis* Sund",

partly, it would seem, collected by himself, and partly previously determined by Adensamer (1898 p. 626) as *P. sivado*. As these, however, are small specimens (30 mm. total length) so that Pesta himself is not certain in his determination, it seems to me most likely that it is really *P. multidentata*, since — apart from the easily distinguishable *P. sivado* — adult specimens of no other species appear to have been found in the Mediterranean.

M. w.	No. of hauls			
	Winter		Summer	
	Night	Day	Night	Day
200— 300	1	3	6	—
900—1200	—	1	2	1
2000—4000	—	1	3	4

Vertical occurrence. Upper limit both day and night lies abt. 200 m.w. In both summer and winter it is taken at night especially with 200—300 m.w. In the daytime, on the other hand, it is taken in winter chiefly with 200—300 m.w. and in summer for the most part with 2000—4000 m.w., not nearer the surface than 1000 m.w.

This species seems to live nearer the surface than *P. tarda* and *P. principalis*. This agrees with the fact of its being a glassy clear, colourless form (Sund 1912 p. 5) for which reason it is called "Glasreke" (glass-shrimp) in Norway. Lo Bianco (1903) however, gives its colour ("*P. tarda*") somewhat otherwise: adult specimens semi-transparent with small red spots. Margin of uropoda and of telson, base and distal part of pereiopoda red. Besides the red spots, there are red bands at the base of the pleopoda. — A fact pointing in the same direction is that its skin is much firmer than in the two other species, which, in specimens of less than ant. 75 mm. is very soft; this applies at any rate to all the specimens at my disposal, and can hardly be altogether due to preservation.

Size and propagation. Nearly all the specimens are comparatively small, 11—49 mm.; only three are larger, viz. 60, 61 and 107 mm. (carapace 33 mm.) and these three are all ♀. Riggio's sole type-specimen of *P. sicula* which should probably be referred to this species, is also a ♀, and even larger: 124 mm., carapace 46.5 mm.

Females with ova have probably never been found in the Mediterranean.

B. Atlantic.

We have only 9 specimens, from seven hauls at seven stations. Localities: Danmark Strait (St. 152, 1904), between the Færöes and Iceland (St. 61 and 285, 1904), SW of Norway (St. 3, 1903), Bay of Biscay (St. 179, 1906 and St. 176, 1909) and Bay of Cadiz (St. 232, 1910). — The three first-mentioned are noted by H. J. Hansen 1908 under *P. tarda*.

In addition to this material, we have in our museum several hundred specimens of this species from the Skagerak (*P. tarda*, K. Stephensen 1909 [1910] p. 287; this material really includes also some true *P. tarda* Kr. and possibly a few *P. principalis*). The measurements for females with ova in this Danish material are as follows:

Length of carapace in mm[1]	17	18	19	20	21	22	23	24	25
Total length in mm	57—59	59—63	59—65	64—70	72—74	69—75	75—78	—	82—84
No. of ♀ with ova	2	8	7	4	2	6	2	—	2

[1] from ocular sinus to hind edge of the carapace.

These dimensions are somewhat smaller than those given by Sund (1912, p. 4) but it is likely that some difference obtains according to locality, and Sund does not state where his specimens were procured.

Apart from the above-mentioned large ♀ from the Mediterranean, ("Thor" St. 122, 1910, 107 mm.) we have in our museum only a single large ♀ (with ova) viz. that from the "Thor" St. 61, 1904, (W. of the Færöes: total length 102 mm., carapace ex. rostrum 30 mm., incl. rostrum 33 mm.).

Distribution.

Mediterranean, especially Western Basin; North Atlantic; Gulf of Maine, S. E. of Greenland; between the Færöes and Iceland; West coast of Europe from Tromsö to Cadiz Bay. —

1. Mediterranean. On the "Thor" see above. — Between Capo Corso and Villafranca, 2000 m.w., daytime closing net, 1 spec.; Capri, 1200—2000 m.w., daytime, and closing net 300 and 400 m.w., daytime, > 4 spec.; Salina (Eolian Isl.), 2500 m.w., daytime, 3 spec. (*P. tarda*, Lo Bianco 1903, p. 185). — Augusta

between Siracusa and Catania, 1 spec. (*P. sicula*, Riggio 1895—96). — ?Adriatic (*P. principalis*, Pesta 1918, p. 67).

2. Atlantic. On the "Thor" see above. — Gulf of Maine, 2 localities, 140—175 fms., several spec. (*P. tarda*, Smith 1879). — S. E. Greenland 58°08′ N, 26°24′ W, 500 m.w. ("Tjalfe" st. 15), 2 spec. 34—59 mm. (O. Sund determ.; *P. tarda* K. Stephensen, "Tjalfe" 1912 (1913), p. 66). — S. of the Færöes (Sund 1912, p. 5). — Norway from Malangen (Tromsö) to Skagerak and Christianafjord (Sund 1912, p. 5). — Almost all the specimens from the Skagerak determined by myself as *P. tarda* (1910, p. 285) belong to *P. multidentata*; the localities are: Skagerak without special localities, several hundred spec.; 58°20′ N, 9°00′ E, 30-6-1907, 350 m., trawl ("Thor" st. 15), 2 spec. abt. 65 mm.; 58°05′ N, 8°24′ E, 23-6-1907, 490 m., 300 m.w., ("Thor" st. 1), 3 spec. abt. 50—60 mm.; North sea at Uggerby, 1 spec. abt. 60 m.w. (Sund determ.); 57°52′ N, 8°1′ E, 6-9-1905 520 m., 300 or 65 m.w., 3 spec. abt. 50—60 mm. ("Thor" st. 173) (Sund determ.); ibid. 300 m.w., 1 spec. abt. 40 mm. (Sund determ.), and 1 spec. abt. 35 mm.; 42 miles N. W. ¾ N. of Hirshals, 9-10-1904, 640 m. ("Thor" st. 273), 2 spec. 30—35 mm. — S. W. Ireland, 370—411 fms. 1 spec. (Kemp 1910). — 73°—45° N, 11° W, 3 spec. (*P. tarda*, Coutière 1911, p. 157, is evidently *P. mult.*, but not *P. principalis*, as this species ("*P. princeps*") is specially mentioned by Coutière and *P. tarda* is never found so far to the south).

2. PASIPHAË PRINCIPALIS Sund.

(Chart 3, partim [p. 28]).

Pasiphæa principalis Sund 1912, p. 4, 6—17, fig. 1 (distribution), figs. 2—4, figs. 5—7 (the right series of figures), fig. 9, a—f; lit. and syn.

?non — Pesta 1918, p. 67 (= ?*P. multidentata*, see this species above p. 29).

Atlantic.

St. 99. 872—970 m. 61°15′ N, 9°35′ W. 22-5-1904. 700—1700 m.w. 24 spec. 24—51 mm. (O. Sund determ.). — St. 63. 1150 m. 59°49′ N, 8°58′ W. 30-5-1905. 1200 m.w. 1 spec. 103 mm. (O. Sund determ.). — St. 74. 1220 m. 59°27′ N, 12°13′ W. 9-6-1906. 2500 m.w., ell drift-seine. 2 spec. 70—76 mm.

On determination etc. see above p. 28; differences from *P. princeps* Smith see Sund, p. 11—12.

Distribution. Davis Straits 63°54′ N, 53°15′ W, 2-6-1909, 988—1400 m. ("Tjalfe" st. 429; O. Sund determ.; by myself ("Tjalfe" 1912 (1913), p. 66 determined as *P. tarda*) 1 spec. 61 mm., carapace 20 mm.). — 65°14′ N, 55°42′ W, 420 fms. ("Ingolf" st. 28; Sund determ.; by H. J. Hansen ("Ingolf" 1908, p. 78) determined as *P. tarda*). — ?S. W. of Iceland 61°44′ N, 27°00′ W, 485 fms. ("Ingolf" st. 81; 1 spec. 37 mm. (Carapace 11 mm.); by Sund determined as "possibly *P. principalis*"; by H. J. Hansen "Ingolf" 1908, p. 78, determined as *P. tarda*). — S. of the Færöes, "Thor" st. 99, 1904, and st. 63, 1905, see above. — S. of the Færöes, "Michael Sars", see Sund 1912, p. 13. — Norway from Lofoten to Sognefjord (Sund 1912, p. 13). — S. W. Ireland: "Thor" st. 74, 1906 (see above), and Sund 1912, p. 13. — 36°—45° N, 11° W, 2 spec. (*P. princeps*, Coutière 1911, p. 157). — North side of Bay of Biscay 48°7′ N, 8°13′ W, 246 fms., 1 spec. 69 mm. (*P. princeps* Kemp, "Huxley" 1910, p. 410).

3. PASIPHAË TARDA Kr.

Pasiphæa tarda Sund 1912, p. 4, fig. 1 (distribution), figs. 2—4, p. 8—9, 12, 14—17, fig. 8, fig. 9, g—n; lit. and syn. Pl. 1—3.

Atlantic.

St. 3. 280 m. 58°52′ N, 4°18′ E. 30-4-1903. 1 spec. 89 mm. (O. Sund determ.).

On determination etc. see above p. 28.

Distribution. Davis Straits, Danmark Straits, Jan Mayen, S. Greenland (see Sund 1912, p. 16). — ?Bredefjord (S. W. Greenland), 26-8-1912, 800 m.w., several spec., total length 11—41 mm. (K. Stephensen 1916, p. 270). — The two localities at W. Greenland in Sund's chart (1912, fig. 1) are situated too far to the north; should be 65°14′ N and 64°14′ N ("Ingolf" st. 28, "Tjalfe" st. 407—08). — N. of Jan Mayen 73°—73°30½′ N, 2°—2°50′ W, 3 localities, 1500—0 and 3000—0 m., 4 spec. (Ohlin 1901). — Skagerak, see Sund 1912, p. 16. The greatest Danish specimen is about 140 mm., (not 150 mm., as given by K. Stephensen 1910, p. 289), carapace abt. 47 mm., but is very defective: rostrum lost, carapace broken, etc. — Was never found in the "Thor"-area S. of 50° N.

4. PASIPHAË SIVADO Risso. (Chart 4, figs. 11—14).

Alpheus sivado Risso 1816, p. 93, Pl. 3 fig. 4.
Pasiphæa — Heller 1863, p. 243, Pl. 8 fig. 4—6 (lit. and syn.).
— Alcock 1901, p. 51 (lit. and syn.).
— Investigator 1892—1907, Crustacea, Pl. 3 fig. 6.
Pasiphaë — Kemp 1910, p. 37, Pl. 4 fig. 12.
Pasiphæa — Pesta 1918, p. 64 (lit.), textfigs. 19—20.

Mediterranean.

St. 10. > 2100 m. 37°21′ N, 16°45′ E. 15-12-1908. 65 m.w., 6^{10} am, 60 min. 2 spec. 34—37 mm. — **St. 10.** ibid. 600 m.w., 3^{45} pm., 60 min. 3 spec.: 2 jun. 12—17 mm., 1 ♂ 53 mm. — **St. 12.** 1060 m. 39°34′ N, 17°17′ E. 19-12-1908. 1000 m.w., 2^{15} pm., 45 min. 2 spec. 17—23 mm. — **St. 13.** > 1200 m. 39°43′ N, 17°30′ E. 19-12-1908. 65 m.w., 8^{50} pm., 60 min. 4 spec. 22, 23, 28, 29 mm. — **St. 14.** 1125 m. 41°24′ N, 17°45′ E. 21-12-1908. 65 m.w., 5^{00} am, 60 min. 3 ♀ (1 with ova 54 mm.) 50—54 mm. — **St. 14.** ibid. 300 m.w., 6^{30} am, 60 min. 1 spec. 42 mm. — **St. 14.** ibid. 1000 m.w., 8^{20} am, 90 min. 1 spec. 34 mm. — **St. 26.** 560 m. 40°41′ N, 13°59′ E. 19-1-1909. 65 m.w., 0^{55} am, 60 min. 2 spec.: 37—48 mm. — **St. 26.** ibid. 300 m.w., 6^{40} am, 180 min. 1 spec. 27 mm. — **St. 27.** 90 m. 40°58′ N, 13°59′ E. 20-1-1909. 25 m.w., 2^{30} am, 180 min. 4 spec.: 1 ♂ 55 mm., 3 ♀ with ova (one of them [53 mm.] with ova also in the ovarium) 53, 60, 60 mm. — **St. 27.** ibid. 65 m.w., 6^{00} am, 120 min. 24 spec.: 11 ♂ (47 mm. [2 spec.], 50, 51, 54 [3 spec.], 56 [2 spec.], 57, 60 mm.), 13 ♀ (2 without ova 46—47 mm., 11 with ova: 50, 51 [2 spec.], 52, 54 [3 spec.], 55 [2 spec.], 56, 62 mm.; 3 of these ♀ have ova also in the ovarium: 52, 54, 54 mm.). — **St. 28.** 600 m. 40°53′ N, 13°43′ E. 19-1-1909. 65 m.w., 11^{50} pm., 120 min. 17 ♀: 2 without ova 46—52 mm., 15 with ova (48, 53 [3 spec.], 54 [2 spec.], 55 [2 spec.], 56, 57, 59, 60 [2 spec.], 61, 63 mm.; of these ♀ 3 spec. have ova also in the ovarium [53, 54, 60 mm.] 1 only in the ovarium [48 mm.]). — **St. 28.** ibid. 1100 m.w., 5^{00} pm., 60 min. 1 spec. 25 mm. — **St. 35.** > 2000 m. 43°36′ N, 7°36′ E. 29-1-1909. 25 m.w., 9^{10} pm., 60 min. 1 ♀ 53 mm. — **St. 35.** ibid. 100 m.w., 7^{55} pm., 60 min. 4 spec.: 2 jun. 29 mm., 1 ♂ 54 mm., 1 ♀ with ova 49 mm. — **St. 35.** ibid. 200 m.w., 6^{40} pm., 60 min. 2 spec. 23—33 mm. — **St. 38.** 105 m. 40°45′ N, 9°50′ E. 31-1-1909. 150 m.w., 8^{20} pm., 30 min. 3 spec. jun. 10, 14, 17 mm. — **St. 47.** > 2000 m. 36°55′ N, 3°12′ E. 10-2-1909. 65 m.w., 10^{20} pm., 30 min. 1 spec. 28 mm. — **St. 61.** 740 m. 35°57′ N, 5°35′ W. 21-2-1909. 600 m.w., 3^{25} pm., 60 min. 3 spec.: 9, 20, 23 mm. — **St. 108.** > 2435 m. 36°03′ N, 0°27′ W. 26-6-1910. 2000 m.w., 0^{40} am, 60 min. 1 spec. 18 mm. — **St. 118.** > 2700 m. 41°00′ N, 6°43′ E. 1-7-1910. 25 m.w., 0^{20} am, 15 min. 2 spec. 30—39 mm. — **St. 118.** ibid. 65 m.w., 11^{35} pm., 30 min. 1 spec. 44 mm. — **St. 122.** > 1500 m. 43°50′ N, 8°34′ E. 2-7-1910. 1200 m.w., 5^{30} pm., 60 min. 4 spec.: 22, 28, 31, 36 mm — **St. 123.** > 600 m. 44°14′ N, 8°55′ E. 3-7-1910. 25 mw., 1^{50} am., 15 min. 21 spec.: 1 ♀ 56 mm, 20 spec. 29—42 mm. (29—31 mm. [5 spec.], 33 [2 spec.], 35 [2 spec.], 37—40 [9 spec.] 42 mm. [2 spec.]). — **St. 123.** ibid. 65 m.w., 0^{55} am, 30 min. 68 spec. 7—47 mm. (7—8 mm. [5 spec.], 10 [4 spec.], 11—15 [14 spec.], 17—18 [10 spec.], 19—20 [5 spec.], 21, 23—25 [7 spec.], 27—30 [7 spec.], 33—35 [6 spec.], 37, 39 [2 spec.], 41, 42, 45—47 mm. [5 spec.]. — **St. 123.** ibid. 300 m.w., 0^{05} am, 30 min. 4 spec.: 10, 13, 18, 31 mm. — **St. 125.** 1082 m. 43°54′ N, 9°13′ E. 9-7-1910. 25 m.w., 10^{30} pm., 30 min. 82 spec.: 4 ♂ 51, 52, 55, 57 mm.; 4 ♀: 1 with ova 62 mm., 3 without ova 53, 58, 61 mm.; 74 spec. 13—50 mm. (13 mm., 23 [2 spec.], 30, 31 [2 spec.], 32—33 [12 spec.], 34—35 [7 spec], 36, 37, 38—40 [8 spec.], 41—43 [11 spec.], 44—45 [14 spec.], 46 [5 spec.], 47—49 [5 spec.], 50 mm. [4 spec.]). — **St. 125.** ibid. 300 m.w., 9^{45} pm., 30 min. 5 spec.: 42, 44, 45, 47, 50 mm. — **St. 126.** 600—620 m. 42°43′ N, 9°50′ E. 10-7-1910. 25 m.w., 10^{10} pm., 30 min. 10 spec. 23—37 mm. — **St. 133.** 600 m. 38°18′ N, 9°59′ E. 14-7-1910. 300 m.w., 10^{15} pm., 30 min. 1 ♀ 64 mm. — **St. 133.** ibid. 600 m.w., 9^{20} pm., 30 min. 1 ♂ 49 mm. — **St. 138.** 820 m. 37°37′ N, 11°25′ E. 19-7-1910. 300 m.w., 9^{10} pm., 30 min. 2 spec. 35—41 mm. — **St. 138.** ibid. 25 m.w., 9^{50} pm., 30 min. 1 spec. 39 mm. — **St. 138.** ibid. 1000 m.w., 7^{40} pm., 60 min. 5 spec.: 2 ♂ 64—75 mm., 3 ♀ 48, 54, 69 mm. — **St. 139.** 530 m. 37°57′ N, 11°54′ E. 20-7-1910. 300 m.w., 2^{35} am, 30 min. 1 spec. 42 mm. — **St. 163.** 1180 m. 37°52′ N, 26°22′ E. 3-8-1910. 300 m.w., 1^{05} am, 15 min. 1 spec. 39 mm. — **St. 175.** 1103 m. 40°48′ N, 27°54′ E. 11-8-1910. 100 m.w, 10^{45} pm., 15 min. 4 spec.: 22, 29, 31, 33 mm. — **St. 175.** ibid. 400 m.w., 11^{20} pm. 30 min. 2 spec. 23—40 mm. — **St. 175.** ibid. 1200 m.w., 0^{25} am, 30 min. 1 spec. 15 mm. — **St. 184.** 850 m. 38°10′ N, 22°35′ E. 17-8-1910. 10 m.w., 1^{50} am, 15 min. 2 spec. 24—38 mm. — **St. 190.** 360 m. 37°51′ N, 15°19′ E. 19-8-1910. 25 m.w., 8^{15} pm., 15 min. 6 spec.: 8, 10, 22, 22, 32, 33 mm. — **St. 192.** 620 m. 38°07′ N, 15°35′ E. 20-8-1910. 25 m.w., 9^{40} pm., 15 min. 1 spec. 26 mm. — **St. 192.** ibid. 600 m.w., 10^{50} pm., 30 min. 2 spec. 29—34 mm. — **St. 209.** > 2000 m. 40°34′ N, 3°03′ E. 29-8-1910. 2000 m.w., 7^{25} am, 45 min. 1 spec. 42 mm. — On the shore at Faro, Messina, 20-3-1911. 1 mutilated spec. 56 mm.

Atlantic.

St. 90. 1012—830 m. 47°47′ N, 8°00′ W. 21-5-1905. 500 m.w., 7^{30} pm., 120 min. 4 spec.: 24, 30, 38, 43 mm. — **St. 167.** 800 m. 57°46′ N, 9°55′ W. 31-8-1905. 65 m.w., 1 spec. 15 mm. — **St. 36.** 1140 m. 44°21′ N, 2°31′ W. 10-5-1906. 300 m.w., 2^{55} am, 120 min. 8 spec.: 6 spec. 42—47 mm., 1 ♂ 63 mm., 1 ♀ 53 mm. — **St. 36.** ibid. 800 m.w., 9^{05} am, 120 min. 6 spec.: 1 ♀ with ova 70 mm., 2 ♀ without ova 53—57 mm., 3 spec. 32, 33, 47 mm. — **St. 36.** ibid. 1250 m.w., 5^{55} am, 120 min. 1 ♂ 60 mm., 1 ♀ 54 mm. — **St. 37.** 1400 m. 44°01′ N, 2°49′ W. 10-5-1909. 300 m.w., 7^{05} pm., 120 min. 33 spec.: 5 spec. 26—38 mm., 7 ♂ 57—68 mm., 4 ♀ with ova 57, 60, 65, 67 mm., 17 ♀ without ova 53—66 mm. — **St. 42.** 348 m. 43°31′ N, 2°13′ W. 15-5-1906. 70 m.w., 10^{30} am, 60 min. 1 spec. 29 mm. — **St. 43.** 1030—1290 m. 43°37′ N, 2°08′ W. 16-5-1906. 600 m.w., 5^{20} am, 120 min. 14 spec.: 7 spec. 28—34 mm., 3 spec. 40—44 mm., 1 ♂ 62 mm., 1 ♀ with ova 63 mm., 2 ♀ without ova 53—56 mm. — **St. 43.** ibid. 250 m.w., 2^{45} am, 120 min. 1 ♂ 70 mm. — **St. 47.** 1015 m. 45°00′ N, 2°57′ W. 17-5-1906. 300 m.w., 2^{25} pm., 120 min. 6 spec.: 5 spec. 13—18 mm., 1 spec. 28 mm. — **St. 168.** 470 m. 51°30′ N, 11°37′ W. 26-8-1906. 300 m.w., 11^{55} pm., 300 min. 3 ♀ 45, 57, 58 mm. — **St. 175.** 1520 m. 51°11′ N, 11°41′ W. 30-8-1906. 300 m.w., hour? 1 ♀ 75 mm. — **St. 185.** 640 m. 51°56′ N, 11°55′ W. 7-9-1906. 600 m.w., 10^{00} am, 60 min. 1 ♀ 72 mm. — **St. 188.** 490 m. 48°12′ N, 8°52′ W. 9-91906. 65 m.w., 30 min., 11^{00} pm., 1 ♀ 52 mm. — **St. 65.** 1300 m. 35°53′ N, 7°26′ W. 24-2-1909. 1600 m.w., 0^{30} pm., 120 min. 1 spec. 25 mm. — **St. 66.** 735 m. 36°16′ N, 6°52′ W. 25-2-1909. 65 m.w., 1^{45} am, 60 min. 8 spec.: 5 spec. 16, 19, 33, 35, 48 mm.; 3 ♀ 52, 52, 57 mm. — **St. 66.** ibid. 300 m.w., 2^{55} am, 120 min. 8 spec.: 3 jun. 16, 39, 47 mm.; 5 ♀ with ova 56, 57, 59, 66, 71 mm. (the spec. 66 mm. has ova only in the ovarium). — **St. 66.** ibid. 600 m.w., 5^{15} am, 120 min. 6 spec.: 4 spec. 17, 21, 25, 41 mm.; 1 ♂ 61 mm., 1 ♀ 65 mm.

— **St. 66.** ibid. 1200 m.w., 8^{30} pm., 120 min. 2 spec. 25—41 mm. — **St. 68.** 550 m. 36°39′ N, 7°21′ W. 27-2-1909. 65 m.w., 7^{00} pm., 15 min. 1 spec. 40 mm. — **St. 68.** ibid. 800 m.w., 5^{55} pm., 45 min. 13 spec.: 12 spec. 18, 28, 32, 32, 33, 37, 40, 41, 42, 43, 45, 47 mm.; 1 ♀ 54 mm. — **St. 71.** 1150 m. 39°35′ N, 9°45′ W. 5-3-1909. 25 m.w., 0^{05} am, 30 min. 0.12 liter. 586 spec. 13—33 mm., most of them (208 spec.) 18—20 mm.: (13—15 mm. [19 spec.], 16—17 [57 spec.], 18 [68 spec.], 19 [69 spec.], 20 [71 spec.], 21—25 [222 spec.], 26—27 [45 spec.], 28—30 [28 spec.], 31—33 mm. [7 spec.]). — **St. 71.** ibid. 65 m.w., 10^{50} pm., 60 min. 22 spec. 14—33 mm. (14 mm., 16—19 [11 spec], 27—30 [7 spec.], 31—33 mm. [3 spec.]). — **St. 71.** ibid. 300 m.w., 8^{40} pm., 120 min. 0.6 liter. 174 spec.: 54 spec. 13—50 mm. (incl. 3 ♀ with ova 48, 48, 50 mm.), 120 spec. 51—69 mm. (13 mm. [1 spec.], 16—20 [10 spec.], 21—25 [15 spec.], 26—30 [17 spec.], 32 mm., 42—43 [4 spec.], 47—50 mm. [6 spec.]. — 48 ♂ 52—69 mm.: 52 mm. [2 spec.], 54 [2 spec.], 56—58 [4 spec.], 59 [8 spec.], 60—63 [20 spec.], 64—65 [6 spec.], 66—69 mm. [6 spec.]. — 28 ♀ without ova 51—65 mm.: 51—52 mm. [4 spec.], 54—55 [2 spec.], 56 [6 spec.], 58 [3 spec.], 59—60 [6 spec.], 61—62 [5 spec.], 65 mm. [2 spec]. — 44 ♀ with ova 52—67 mm. [of which 4 have ova only in the ovarium: 54, 55, 61, 64 mm.]: 52 mm., 53—54 [4 spec.], 55—58 [15 spec]. 59—60 [6 spec.], 61 [6 spec.], 62—64 [7 spec.], 66—67 mm. [5 spec.]). — **St. 71.** ibid. 600 m.w., 6^{35} pm., 120 min. 55 spec.: 34 spec. 14—50 mm. incl. 1 ♀ with ova 50 mm., 7 ♂ 60—64 mm. 14 ♀ 51—67 mm. (14—15 mm. [2 spec.], 16—17 [4 spec.], 19—20 [5 spec.], 21—25 [5 spec.], 26 [2 spec.], 28—29 [4 spec.], 34, 36, 37, 38, 40 [2 spec.], 43, 45 [4 spec.], 50 mm. [1 ♀ with ova]. — 7 ♂: 60 mm. [5 spec.], 62, 64 mm. — 4 ♀ without ova 58, 59, 65, 67 mm. — 10 ♀ with ova: 51, 53, 54, 55 [3 spec.], 56 [2 spec.], 59, 62 mm.). — **St. 71.** ibid. 1600 m.w., 4^{00} pm., 120 min. 129 spec.: 116 spec. 10—47 mm., 7 ♂ 51—66 mm., 6 ♀ 51—63 mm. — (10—12 mm. [13 spec.], 13—15 [35 spec.], 16 [18 spec.], 17—18 [20 spec.], 19—20 [13 spec.], 21, 23—27 [8 spec.], 38, 41, 42, 43, 44 [2 spec.], 45, 47 mm. — 7 ♂: 51, 60, 61, 62, 64, 65, 66 mm. — 2 ♀ with ova 51—68 mm., 4 ♀ without ova 55, 57, 60, 63 mm.). — **St. 74.** >2000 m. 44°21′ N, 7°55′ W. 9-3-1909. 600 m.w., 0^{10} am, 60 min. 2 spec. 26 mm. — **St. 74.** ibid. 65 m.w., 1^{30} am, 60 min. 2 spec., 17—22 mm. — **St. 76.** 1000 m. 47°01′ N, 5°48′ W. 10-3-1909. 25 m.w., 7^{15} pm., 30 min. 0.4 liter, 115 spec.: 48 spec. 27—50 mm., 21 ♂ 51—65 mm., 33 ♀ without ova 51—60 mm., 13 ♀ with ova 55—67 mm. (27—28 mm. [5 spec.], 29, 30, 32—33 [4 spec.], 34, 36, 38—40 [7 spec.], 41, 42, 43—45 [8 spec.], 46—47 [4 spec.], 48—50 mm. [14 spec.]. — 21 ♂: 51—52 mm. [3 spec.], 53—54 [5 spec.], 55 [2 spec.], 57 [4 spec.], 60 [3 spec.], 62, 63 [2 spec.], 65 mm. — 33 ♀ without ova: 51 mm. [4 spec.], 52 [7 spec.], 53 [3 spec.], 54 [5 spec.], 55 [5 spec.], 56—58 [6 spec.], 59, 60 mm. [2 spec.]. — 13 ♀ with ova: 6 have ova only in the ovarium: 55, 57 [2 spec.], 58, 60, 67 mm., 7 have ova only under the abdomen: 55 [2 spec.], 58, 59, 64 66, 67 mm.). — **St. 76.** ibid. 65 m.w., 6^{05} pm., 60 min. 32 spec.: 22 spec. 23—50 mm., 5 ♂ 52—58 mm., 5 ♀ 52—62 mm. (23, 26, 28, 30 (4 spec.], 33 [3 spec.], 34, 35 [2 spec.], 37, 38, 41, 46 [2 spec.], 48 [2 spec.]. 50mm. [2 spec.].— 5 ♂: 52, 53, 54, 57, 58 mm. — 4 ♀ without ova: 52 [2 spec.], 57, 62 mm., 1 ♀ with ova 58 mm.). — **St. 76.** ibid. 300 m.w., 11^{30} am, 60 min. 17 spec. 11—15 mm. — **St. 76.** ibid. 600 m.w., 1^{15} pm., 60 min. 75 spec. 9—29 mm. (9—10 mm. [5 spec.], 11 [6 spec.], 12—13 [26 spec.], 14—15 [18 spec.], 16—17 [8 spec.], 18 [2 spec.], 19, 20, 21 [4 spec.], 22, 23, 26, 29 mm.). — **St. 76.** ibid. 1600 m.w., 2^{40} pm., 60 min. 27 spec.: 8 spec. 21—37 mm., 2 spec. 41—48 mm.; 8 ♂: 53, 57, 61, 63, 66 (2 spec.), 67, 70 mm.; 9 ♀: 3 without ova 58—60 mm., 6 ♀ with ova: 57, 60, 61 (3 spec.), 64 mm. — **St. 77.** 100 m. 48°43′ N, 4°45′ W. 11-3-1909. 65 m.w., 3^{15} pm., 30 min. 1 spec. 10 mm. — **St. 80.** >4000 m. 46°17′ N, 7°31′ W. 13-6-1910. 25 m.w., 10^{45} pm., 15 min. 1 spec. 28 mm. — **St. 80.** ibid. 65 m.w., 10^{00} pm., 30 min. 2 spec. 33—34 mm. — **St. 80.** ibid. 300 m.w., 10^{05} pm., 30 min. 20 spec.: 1 spec. 23 mm., 19 spec. 33—45 mm. — **St. 81.** 2140 m. 41°32′ N 9°32′ W. 15-6-1910. 500 m.w., 4^{50} pm., 30 min. 8 spec. 33—47 mm. — **St. 91.** 1225 m. 35°53′ N, 7°26′ W. 18-6-1910. 1600 m.w., 5^{25} pm., 60 min. 1 spec. 31 mm. — **St. 92.** >500 m. 36°16′ N, 6°50′ W. 19-6-1910. 65 m.w., 3^{40} am, 30 min. 18 spec.: 17 spec. 24—34 mm., 1 spec. 41 mm. — **St. 231.** 1000 m. 35°56′ N, 7°16′ W. 9-9-1910. 300 m.w., 1^{15} pm., 30 min. 1 ♀ 60 mm. — **St. 233.** 658 m. 36°49′ N, 9°15′ W. 10-9-1910. 25 m.w., 5^{05} am, 15 min. 6 spec., 37—40 mm. — **St. 234.** 920 m. 38°10′ N, 9°20′ W. 10-9-1910. 25 m.w., 9^{45} pm., 30 min. 0.7 liter = 415 spec.: 6 ♂, 26 ♀, 383 spec. 32—50 mm. (32—33 mm. [3 spec.], 34—35 [16 spec.], 36 [24 spec.], 37 [31 spec.], 38 [38 spec.], 39—40 [91 spec.], 41 [36 spec.], 42 [24 spec.], 43 [31 spec.], 44 [26 spec.], 45 [17 spec.], 46 [11 spec.], 47 [8 spec.], 48 [13 spec.], 49—50 [16 spec.] — 6 ♂: 51, 51, 53, 54, 54, 70 mm. — 26 ♀ (none with ova) 51, 52 [4 spec.], 53 [3 spec.], 54 [5 spec.], 55 [6 spec.], 58 [2 spec.]). — **St. 234.** ibid. 300 m.w., 10^{30} pm., 30 min. 22 spec. 3 ♂ 52, 56, 58 mm. — 6 ♀: 1 with ova 60 mm., 5 without ova 51, 56, 57, 58, 59 mm. — 13 spec. 33—48 mm.: 33 mm., 35 [3 spec.], 37, 38, 39—40 [4 spec.], 44, 47, 48 mm. — **St. 234.** ibid. 1000 m.w., 11^{20} pm., 30 min. 11 spec.: 4 spec. 38—40 mm., 4 spec. 48—50 mm.; 1 ♂ 69 mm., 2 ♀ with ova in the ovarium 56—60 mm. — **St. 240.** 2500 m. 44°30′ N. 8°16′ W. 15-9-1910. 300 m.w., 9^{00} pm., 15 min. 1 ♀ with ova in ovarium 63 mm. — **St. 242.** 4941 m. 46°19′ N, 6°48′ W. 16-9-1910. 65 m.w., 10^{55} pm., 30 min. 3 spec.: 33, 35, 40 mm. — **St. 244.** 960 m. 47°08′ N, 6°08′ W. 17-9-1910. 1000 m.w., 10^{25} am, 30 min. 5 spec.: 12, 13, 14, 30, 37 mm. — **St. 245.** >460 m. 47°14′ N, 6°12′ W. 17-9-1910. 65 m.w., 9^{55} pm., 15 min. 0.6 liter = 208 spec.: 124 spec. 18—50 mm., 16 ♂ 55—69 mm., 68 ♀ 51—68 mm. (18 mm., 21, 22 [3 spec.], 25, 26—27 [4 spec.], 28, 29 [3 spec.], 30, 32 [3 spec]., 33 [4 spec.], 34 [2 spec.], 35 [5 spec.], 36—37 [6 spec.], 38, 39—40 [6 spec.], 41 [5 spec.], 42—43 [18 spec.], 44 [4 spec.], 45 [10 spec.], 46 [4 spec.], 47—48 [21 spec.], 49 [9 spec.], 50 [11 spec.]). — 16 ♂: 55, 56, 57, 58, 60 [3 spec.], 62 [5 spec.], 63, 64, 68, 69 mm. — 50 ♀ without ova: 51 [3 spec.], 52, 53 [2 spec.], 54—55 [6 spec.], 56 [4 spec.], 57 [7 spec.], 58, 59—60 [6 spec.], 61 [7 spec.], 62 [3 spec.], 64 [4 spec.], 65 [3 spec.], 67 [2 spec.], 68 mm. — 18 ♀ with ova: 6 with ova only in the ovarium: 60 [2 spec.], 61 [3 spec.], 64 mm.; 1 with ova both in the ovarium and on the abdomen: 66 mm.; 11 with ova only on the abdomen: 62, 63 [2 spec.], 65, 66 [2 spec.], 67, 68 [3 spec.], 69 mm.). — **St. 245.** ibid. 150 m.w., 15 min., 8^{55} pm. 21 spec.: 2 spec. 21—28 mm., 5 spec. 37—46 mm.; 4 ♂: 58, 59, 60, 64 mm.; 1 ♀ with ova only in the ovarium 63 mm.; 9 ♀ without ova: 57 [2 spec.], 58, 59, 60 [2 spec.], 62 [2 spec.], 63 mm. — **St. 245.** ibid. 400 m.w., 5^{15} pm., 120 min. 0.7 liter = 268 spec.: 134 spec. 15—50 mm., 41 ♂

54—74 mm., 93 ♀ 51—73 mm. (15—17 mm. [7 spec.], 18—19 [6 spec.], 20 [8 spec.], 21 [6 spec.], 22 [4 spec.], 23—24 [5 spec.], 25 [4 spec.], 26 [2 spec.], 27 [6 spec.], 28 [3 spec.], 29 [5 spec.], 30 [2 spec.], 31 [4 spec.], 32, 33, 34 [3 spec.], 35—39 [5 spec.], 40 [2 spec.], 41, 42 [3 spec.], 43 [12 spec.], 44 [3 spec.], 45—46 [9 spec.], 47 [2 spec.], 48 [9 spec.], 49 [4 spec.], 50 mm. [17 spec.], — 41 ♂: 54, 56, 57 [2 spec.], 58, 59 [2 spec.], 60 [5 spec.], 61—62 [5 spec.], 63, 64—65 [5 spec.], 66, 67 [4 spec.], 68 [2 spec.], 69, 70 [3 spec.], 71—72 [4 spec.], 73, 74 mm. — 38 ♀ without ova: 51, 52 [2 spec.], 53, 54 [3 spec.], 56 [3 spec.], 57 [5 spec.], 58—59 [4 spec.], 61—62 [6 spec.], 63 [2 spec.], 64—65 [8 spec.], 66, 67, 70, 71 mm. — 55 ♀ with ova: 26 with ova only in the ovarium: 59, 60, 61—62 [6 spec.], 63—64 [11 spec.], 65—67 [6 spec.], 68 mm.; 3 ♀ with ova both in the ovarium and on the abdomen: 60, 64, 70 mm.; 26 ♀ with ova only on the abdomen: 55, 61 [2 spec.], 63 [3 spec.], 64 [2 spec.], 65 [4 spec.], 66 [3 spec.], 67 [2 spec.], 68, 69 [5 spec.], 70, 71, 72 [2 spec.], 73 mm.).

The material contains totally 2672 spec. (197 ♂ > 50 mm., 442 ♀ > 50 mm., 2033 spec. 10—50 mm.) from 55 stations, 95 hauls.

Variation (Mediterranean and Atlantic). (Fig. 11).

In seeking for characters to show how far specimens from the Mediterranean differ from those from the Atlantic or not, I found that the spines on the inferior margin of the merus in p. 1—p. 2 really exhibit such a difference, though it is not always possible to tell, by counting the spines on any specimen at hazard, from which region it came.

The basis of p. 1—p. 2 always terminates in a single spine; the ischium is smooth on the lower margin, but the merus has a varying no. of spines. In order to be sure that the no. of spines did not vary with the age of the specimen, I have only examined specimens of 50 mm. or over, (total length). In the Mediterranean material, I examined all specimens of this size having the two mentioned pairs of legs undamaged; there were 62 such specimens in all. From the Atlantic, I selected a number of specimens from those stations which had yielded the greatest number of large individuals, viz. St. 71 (5-3-1909, 39°35′ N, 138 spec.), St. 76 (10-3-1909, 47°01′ N, 76 spec.) and St. 245 (17-9-1910, 47°14′ N, 127 spec.) In choosing these particular stations, I had also the advantage of having one station N. of 40°, both spring and autumn, and also one station S. of 40° N (spring; no other station had given a greater no. of large specimens). If any seasonal or local difference existed, (as a result of migration or from similar causes) it would then appear.

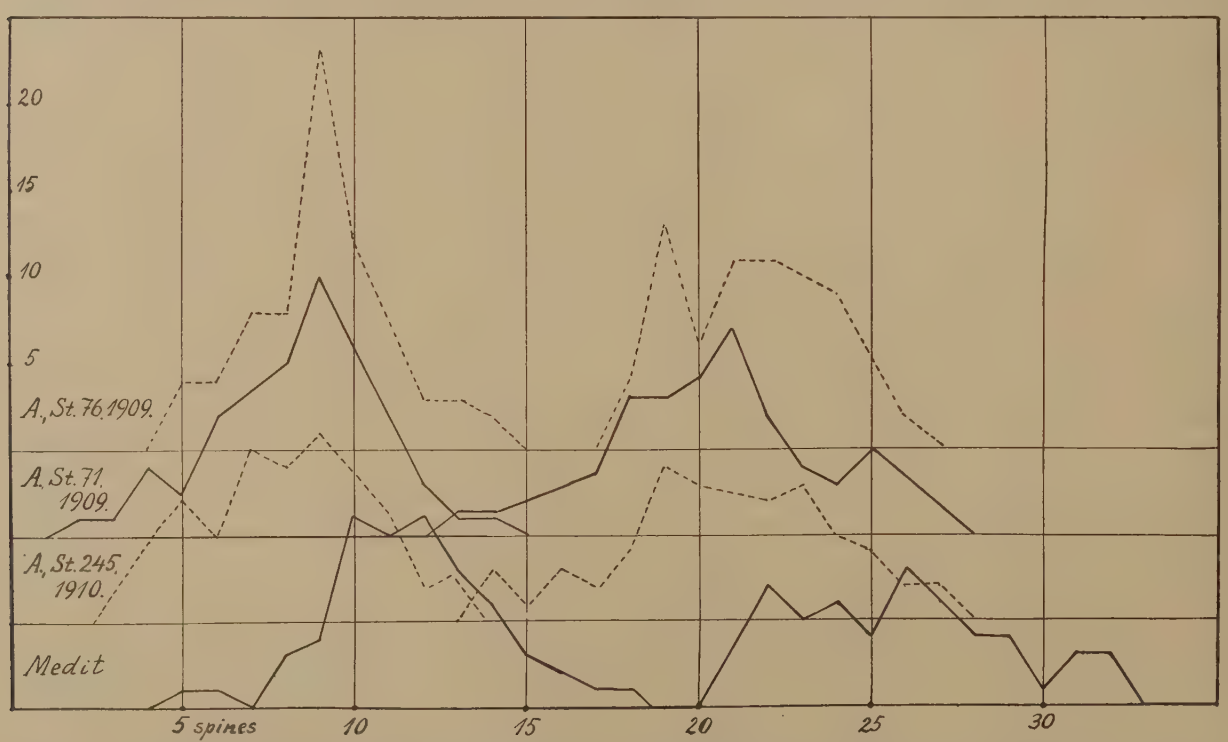

Fig. 11. Pasiphaë sivado. Number of spines on the underedge of the merus of the two pereiopods of 1. pair (to the left) and 2. pair (to the right) in the Atlantic (A) at 3 different stations and in the Mediterranean (Medit.). The Stations 71 and 245 have given twice as many specimens as noted.

As it proved, however, these three Atlantic stations agreed very well together, in contrast to the Mediterranean, which presented an entirely different appearance.

	No. of specimens			
	Medit.	Atlantic		
		St. 71	St. 76	St. 245
Total no. of specimens	62	138	76	127
The two p. 1 have equal no. of spines	22	49	22	41
The two p. 2 have equal no. of spines	22	44	17	32
These characters combined	4	14	6	10

From this it will be seen that only abt. 30% have the same no. of spines on the two p. 1; a somewhat smaller percentage (abt. 20—25%) have the same no. of spines on both p. 2, not 10% have these two characters combined.

In most cases (abt. 40% of all specimens) one leg on the one side has 1 spine more than the corresponding leg on the other side, more rarely (abt. 15%) they differ by 2, still more rarely again the difference may be 3 or 4; the greatest difference noted was 7, one specimen from St. 71 having 3 spines on the one p. 2 and 10 on the other. In this respect, the same principle seems to apply to p. 1 and p. 2.

The absolute limits for no. of spines on the merus of p. 1 and p. 2 in a single specimen are 10 and 51; these, however, are unique exceptions. The 10 is thus obtained: the two p. 1 have no spines, the two p. 2, 4 and 6 respectively (St. 71, 1909). The 51 case (a specimen from the Mediterranean) had 7 on each of the two p. 1, and 18 and 19 respectively on p. 2. A single specimen (also from the Mediterranean) has 50 spines in all. Otherwise, the figures lie between these limits, and it can be stated as a rule that the more spines there are on p. 1, the more there will also be on p. 2; this also appears from the fig. 11).

As shown in fig. 11, the specimens from the Atlantic differ from those of Mediterranean origin in regard to no. of spines. The majority of the Mediterranean specimens have, on both p. 1 together, 10—12 spines, whereas the figure for material from the three Atlantic stations above noted is 9; in the case of p. 2, the figures are 22—26 and 19—21 (23) respectively. It will thus be seen that while the three Atlantic stations, albeit differing in regard to season and locality, are in excellent agreement on this point, the Mediterranean material is different.

A. Mediterranean.

The material contains 308 spec. (18 ♂ > 50 mm., 39 ♀ > 50 mm., 251 spec. 10—50 mm.) from 26 stations, 44 hauls.

	Stations	Hauls	No. of specimens			
			♂ > 50 mm.	♀ > 50 mm.	Spec. 10-50 mm.	total
Dec. 1908	4	7	1	2	13	16
Jan. 1909	5	10	10	29	19	58
Feb. —	2	2	—	—	4	4
June 1910	1	1	—	—	1	1
July —	8	15	7	8	194	209
Aug. —	6	9	—	—	20	20
total	26	44	18	39	251	308

Depth of sea and occurrence. The relatively greater part of the stations are 500—1000 m. deep, but it has been taken at stations down to abt. 3000 m. Three stations show a depth to bottom of less than 500 m., viz. 90, 105 and 360 m.

Depths in m.	No. of stations
0—500	3
> 500—1000	10
> 1000—2000	7
> 2000—3000	6
> 3000	—
total	26

It will be seen from Chart 4, that it is distributed throughout the whole of the Mediterranean with the exception of the southern part of the eastern basin; it goes right up into the Marmora, and in the southern portion of the Adriatic, but there are more stations in the western than in the eastern basin. It is not so numerous, however, as in the Atlantic: 44 hauls yielded 308 specimens (or 7 per haul) against 51 hauls giving 2376 specimens (45 per haul) in the Atlantic.

It does not appear to thrive equally well in both basins. The eastern gave 36 specimens in 16 hauls (2.3 per haul) and showed no difference as between summer and winter. The western, on the other hand, yielded 272 specimens in 28 hauls (9.8 per haul) with a rather marked difference according to season: summer 16 hauls, 210 spec., (13.1 per haul), winter 12 hauls only 63 spec. (5.2 per haul).

In the night hauls, practically all specimens, both large and small, summer and winter were taken with 65—100 m.w.; hardly any were taken outside these limits.

In the daytime, it was taken during winter with

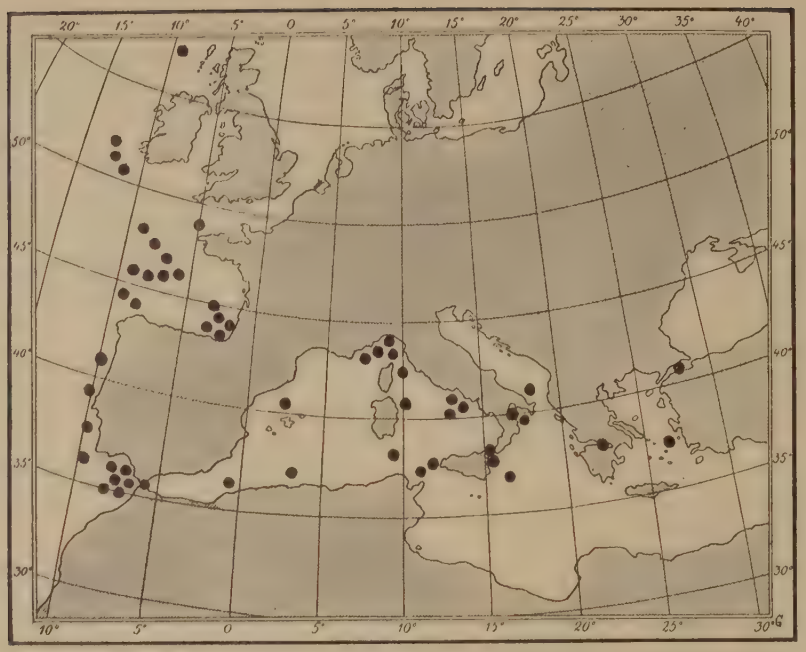

Chart 4. Pasiphaë sivado.

65—1100 m.w., and in summer (only 2 hauls in all, 5 specimens) with 1200—2000 m.w.

Shoals may occur, but almost exclusively in summer. The occurrence of shoals is always caused by the presence of a great number of small individuals; shoals are never composed exclusively of adult specimens (over 50 mm.). That the shoals are only met with in summer is doubtless due to the fact that the whole process of spawning takes place, practically speaking, only in winter (*vide infra*) so that at this season — (save for newly hatched specimens, which are not found in the "Thor" material) only large specimens would be met with, and these, as mentioned, do not form shoals. The largest no. of specimens from a single haul (of 30 minutes) was 82.

Size and propagation. Among specimens over 50 mm., there are twice as many ♀ as ♂ (39 and 18) but the sizes for the two sexes are about the same, as a rule not more than 64 mm., though we have a single ♀ of 69, and a single ♂ of 75 mm.

Females with ova are practically speaking only met with in winter (Dec.—Feb.); at this season, a total of 31 ♀ over 50 mm. was taken, and of these only 3 (52—54 mm) were without ova, all the remaining 28 ♀ (51—63 mm.) with ova, either in the ovarium (where they are very easily discernible, showing through the skin) or under the abdomen, or both together. (The material also includes 3 smaller ♀ with ova, viz. one of 48 mm. with ova in the ovarium, and 2, of 49 and 50 mm., with ova under the abdomen). It is thus seen that all females over 54 mm., besides several of the smaller ones, have ova. It will further be noticed that it is only the smaller ♀, (52—54 mm., with a single individual of 60 mm.) which have ova both in the ovary and under the abdomen; it would seem, then, that the largest ones lay their eggs first, the smaller coming on a little later (as in the Atlantic, see fig. 13).

In summer, on the other hand, 8 ♀ over 50 mm. were taken in all, of which only one had ova.

We may thus take it for granted that the spawning takes place only in winter. Nevertheless, owing to the small number of specimens, we have not succeeded in determining the age and growth of the individuals. Despite endeavours to range them in order of size, it is impossible to say with certainty whether the egg-bearing individuals are 1 or 2 years old; probably, however, the majority of these are only 1 year old, since we can doubtless take it for granted that they agree in this respect with those from the Atlantic S. of 40° N (*vide infra*). It seems, nevertheless, not impossible that some few may be older, for we have in the "Thor" material one or two of especially large size (1 ♀ 69 mm., 1 ♂ 75 mm.) taken in summer; these would probably be $1^1/_2$ years old.

B. Atlantic.

The material contains 2364 spec. (179 ♂ > 50 mm., 403 ♀ > 50 mm., 1782 spec. 10—50 mm.), from 29 stations, 51 hauls.

♀, Mediterranean, Winter

Length in mm	51	52	53	54	55	56	57	58	59	60	61	62	63	total
Without ova	—	1	1	1	—	..	..	..	..	..	..	..	..	3
Ova both in the ovar. and on the abdom.	—	1	2	3	—	..	..	..	—	1	—	..	..	7
Ova only on the abdomen	2	—	2	3	4	2	1	—	1	3	1	1	1	21

	Stations	Hauls	No. of specimens ♂ > 50 mm.	♀ > 50 mm.	spec. 10—50 mm.	total
May 1905	1	1	—	—	4	4
Aug. —	1	1	—	—	1	1
May 1906	5	8	11	29	31	71
Aug. —	2	2	—	3	1	4
Sept. —	2	2	—	2	—	2
Feb. 1909	3	7	1	10	28	39
Mar. —	4	13	96	152	989[1]	1237
June 1910	4	6	—	—	50	50
Sept. —	7	11	71	207	678	956
total...	29	51	179	403	1782	2364

[1] including 4 ♀ with ova 48—50 mm.

Depth of sea and occurrence. Depth of sea generally 500—2000 m.; the 5 stations with depth to bottom less than 500 m. were as follows: 100, 348, over 460, 470 and 490 m.

Taken by the "Thor" from the Bay of Cadiz up to N. of Ireland; 5 stations situate far up in the Bay of Biscay, one at the mouth of the Channel.

Depth in m.	No. of stations
0— 500	5
> 500—1000	10
> 1000—2000	9
> 2000—3000	3
> 3000—4000	—
> 4000	2

Vertical occurrence. 1. N. of 40° N. The hauls here did not on the whole yield any great number of specimens, and the results can therefore not be taken as very reliable. For the night hauls in summer, 214 out of a total 355 specimens were taken with 65—70 m.w.; this depth, then, is the most frequent. Only 1 spec. was taken nearer the surface (25 m.w.) and only 2 with over 600 m.w. In winter (night) on the other hand, 115 out of 151 were taken with only 25 m.w. In the day-time, most were taken with 250—400 m.w. (summer) and 600 m.w. (winter) at both seasons, however, some few were taken with 65 m.w.

Kemp (Ireland 1910 p. 39) seems to take it for granted that the species is a bottom form, though he states that specimens less than 30 mm. can be met with "in midwater, and less commonly at the surface". That he is not correct in thus presuming it to live on the bottom is evident from the fact that practically all the hauls from the "Thor" were made with a length of line reaching only a fraction of the distance to bottom at the stations concerned.

The specimens appear to be distributed evenly, irrespective of size, throughout the area within which the species is at all frequent (see list of localities, especially St. 76, 1909 and St. 245, 1910); St. 76, 1909 indeed, shows that large specimens can at night be met with close to the surface (25 m.w.) in great numbers.

2. S. of 40° N. In the first place, the material from this area is far greater than that from the northern waters, and further, a couple of stations — and one especially, (St. 71, 5-3-1909) yielded a very large number of specimens. (See fig. 12). Night hauls from this station with 25 m.w. yielded 586 specimens of 13—33 mm. of which 208 were only 18—20 mm. With 65 m.w. only a few specimens were taken, but similar in size, whereas 300 m.w. gave, in addition to a number of small ones, 119 specimens over 50 mm. Females with ova were never found at all nearer the surface. St. 234 (10-9-1910) which, it is true, yielded nothing under 30 mm., supplements the results from the first-mentioned station in showing that larger specimens (30 to over 60 mm.) may occur in the autumn, as contrasted with March, near the surface, while, as in March, most of the larger specimens (over 50 mm.) keep to a depth answering to 300 m.w.

At night, in both spring and autumn, 25 m.w. seems to give the depth yielding relatively greatest nos. of specimens; depths over 300 m.w. yielded only very few.

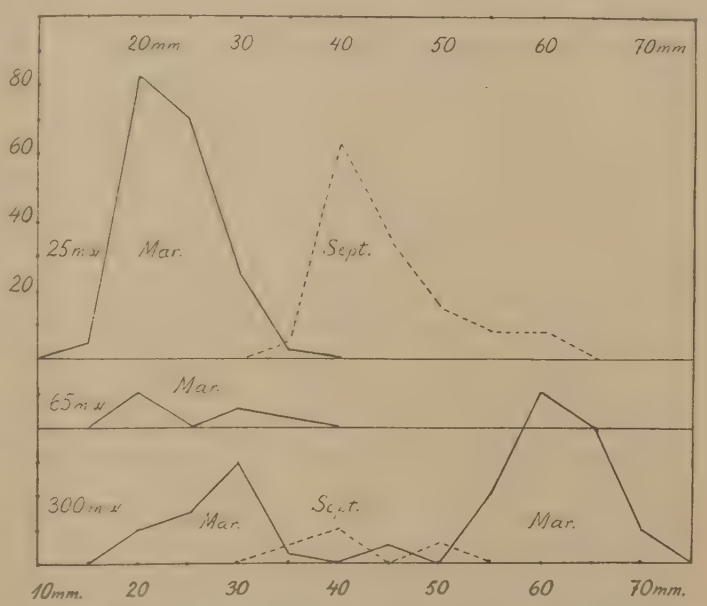

Fig. 12. Pasiphaë sivado. Sizes of specimens taken at night with 25, 65 and 300 m.w. in the Atlantic S. of 40° N. in March (St. 71, 5-3-1909) and Sept. (St. 234, 10-9-1910). (St. 71, 25 m.w., has given twice as many specimens as noted).

In the daytime, some specimens were taken with 300—1600 m.w.

Shoals are quite frequently met with, and may be found both in summer and winter both S. and N. of 40° N, but not N. of 50° N, where four hauls (summer) yielded only 1 specimen.

The 51 hauls yielded 2364 specimens, or abt. 46 per haul. Several hauls showed a very large yield, abt. 0.5 litre or even more in the course of 30 minutes. The greatest number of individuals is 586 (30 minutes) but most of the specimens in the larger hauls are small, under 50 mm.

Greatest average no. of specimens per haul is found S. of 40° N, where 7 summer hauls showed an average of abt. 67 specimens, while 12 winter hauls gave each abt. 84 specimens. Between 40° and 50° N, we have 20 summer hauls, giving an average of 31 spec., and 8 winter hauls, with very similar average, viz. abt. 34. It is thus far more numerous in the Atlantic than in the Mediterranean.

Size and propagation. The size of the ova is 1×0.8 mm. Balss (1914, p. 20) gives the dimensions as 1×1.44 mm. for a ♀ from Japan.

As almost the entire yield of larger specimens (over 50 mm.) is derived from 4 stations (St. 71 and 76 1909, St. 234 and 245 1910) the following observations are based exclusively on the results from these 4 stations.

The yield of specimens over 50 mm. amounted to 167 ♂, 357 ♀, i. e. fully twice as many ♀ as ♂, and this proportion is also found more or less for the separate stations (as in the Mediterranean); the greatest difference is seen at St. 234 (34 ♀, 10 ♂). The two sexes appear to be altogether alike in regard to size; the largest specimens are 73—74 mm. Relatively, however, there are more ♂ than ♀ among the largest specimens, (70—74 mm.) viz. 11 ♂, 8 ♀. According to the literature, the size may go up to abt. 100 mm (4 ins. Henderson, Proc. & Trans. Nat. Hist. Soc. Glasgow, vol. 1, 1886).

Propagation. Females with ova were found both N. and S. of 40° N.

The survey in fig. 13 (St. 245, 1910) shows that females with ova are found for the most part among the largest specimens; from the list of localities (especially stations 76, 1909, and 245, 1910) it will be seen, not only that specimens with ova are mostly larger than those without, but also that the smallest females with ova often have these only in the ovary, not under the abdomen, while those with all the ova under the abdomen are often the largest individuals from the station concerned. (As in the Mediterranean). It would seem then, that the ♀ grow several mm. while bearing the ova (in the ovary or under the abdomen) which again suggests that the egg take some considerable time to hatch out.

Spawning period. N. of 40° N, ♀ were found in the months of March, May and Sept. Kemp, (Ireland 1910) states (p. 7) that females with ova are found in Jan., Feb. and March (locality not stated) and in May off the coast of Ireland. In his list of Irish localities, however, (p. 38—39) he gives only a few finds from 1.—18. May. In the "Thor" material, we have, save for St. 76 and 245 in the northern area, only found very few females, and the fact that the few hauls made at all outside the months allready mentioned (March, May, September) did not yield females with ova therefore affords no proof that the species in these waters does not also spawn in the summer proper.

Station 76 (1909) and St. 245 (1910) yielded nearly

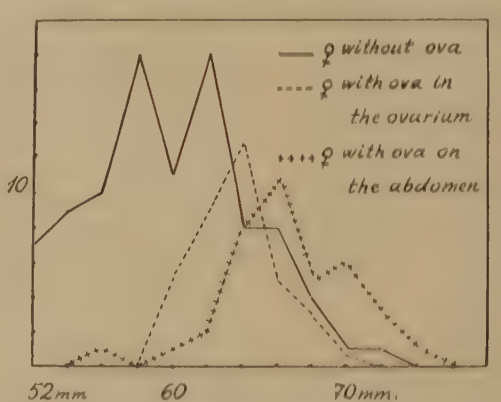

Fig. 13. Sizes of Pasiphaë sivado from St. 245, 19-9-1910. (4 of the ♀ with ova in the ovarium had also ova on the abdomen).

all the ♀ taken anywhere N. of 40° N, and it will therefore suffice to keep to these two stations. St. 76 (10-3-1909) gave 60 ♀ over 50 mm. of which 20 with ova, or 33%. St. 245 (17-9-1910) gave 171 ♀ over 50 mm.; 74 with ova, or 43%. These figures alone suggest that the summer (or more correctly, the latter part of the summer) is more usual as a spawning season than the spring, even though the extant information otherwise shows that the species can spawn at almost any season.

In order if possible to ascertain by other means the commonest period of spawning (and the age) curves have been drawn showing size of individuals from these two stations (fig. 14). St. 76 (March) shows a maximum of individuals 15 and 55 mm., while St. 245 (Sept.) has two maxima at 50 and 65 mm. separated by a minimum at 55 mm. While realising that the true state of things may be obscured by the fact that the species can practically speaking propagate at any season, these curves can nevertheless admit of no other explanation than

that the specimens of 15 mm. (March) and 50 mm. (Sept.) commenced their existence in summer (or late summer) of the previous year, whereas the two maxima of 55 mm. (March) and 65 mm. (Sept.) apply to individuals of $1^1/_2$ and $2^1/_2$ years old respectively. The existence at the same point (55 mm.) of a minimum for specimens taken in September and maximum for specimens taken in March seems to suggest that the foregoing is correct. That the animals grow more during summer than in winter seems evident from the position of the March maximum (55 mm.) which shows — always presuming the foregoing to be correct — that the specimens only grew 5 mm. since Sept. of the previous year, (viz. from 50 to 55) whereas in the following summer they will grow 10 mm. (from 55 to 65 mm.).

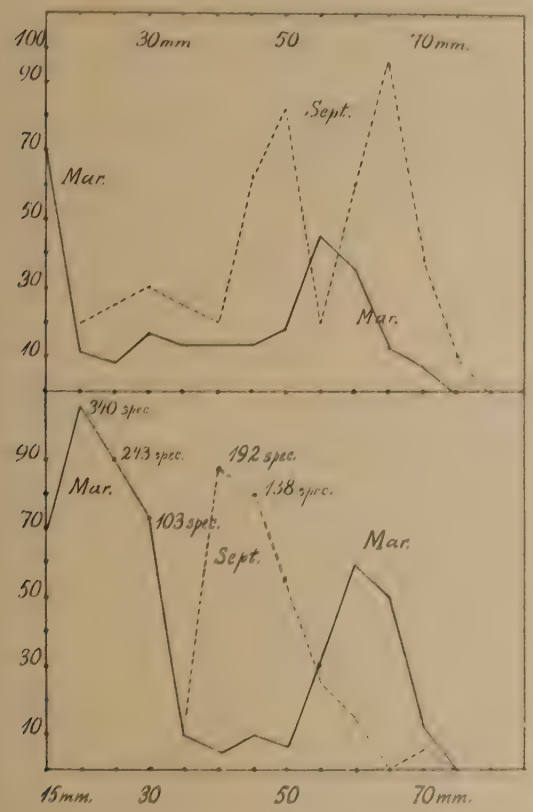

Fig. 14. Pasiphaë sivado. Sizes of specimens N. of 40° N. (above) in March (St. 76, 1909) and Sept. (St. 245, 1909) — and S. of 40° N. (below) in March (St. 71, 1909) and Sept. (St. 234, 1910).

As females with ova are at least 55 mm., and for the most part considerably larger, they must then be 2 years old before spawning.

S. of 40° N we find a much simpler state of affairs. Spawning takes place practically speaking only in winter (or at any rate early spring) i. e. as in the Mediterranean. The following observations are based solely on results from the two largest stations in this area, St. 71 (5-3-1909) and St. 234 (10-9-1910). In March (St. 71) we have 92 ♀ over 50 mm. of which 56 with ova (+ 4 spec. 48—50 mm) i. e. abt. 60%. In September (St. 234) on the other hand, 31 ♀ were taken without ova, and only 3 with; (at all other stations, in the summer half of the year [the "Thor" has only stations for September] no ♀ with ova were taken at all). The curves for the southern area are therefore much easier to understand than those for the northern waters; we have in March, maxima at 20 and 60 mm., in Sept. at 40 mm. Those specimens which measured 20 mm. in March must naturally have been hatched out some months earlier (some few females with ova have indeed been found in February, but not in other months during the winter half-year). As there are uniform intervals between the three maxima (20—40—60 mm.) it is thus evident that the species here, in contrast to the northern area, grows at an equal rate both summer and winter. This again gives a more rapid rate of growth on the whole (specimens of abt. 1 year old measure 60 mm. as against 50 farther north), so that females with ova would hardly be more than 1 year old and much smaller than in the northern waters (Station 71 alone yielded 16 ♀ with ova, 50—56 mm., whereas in the northern area, the two largest stations above mentioned gave no females with ova at less that 55 mm., and only 4 specimens in all of sizes from 55—56 mm.). These results also appear to agree well with what is noted for the Mediterranean.

Summary.

Individuals in the Mediterranean differ from those found in the Atlantic in having somewhat larger no. of spines on the lower margin of the merus in p. 1 and p. 2.

The species lives pelagically over great depths of sea. At night, it is taken more especially from the surface down to 100 m., which agrees with its colouring: glassy clear with red spots (Kemp, Ireland 1910 p. 38). The smaller specimens live as a rule nearer the surface, the large ones often deeper down (as far as 300 m.w.) but females with ova may be met with at the surface both in the Atlantic and the Mediterranean. Females with ova are as a rule over 50 mm. Spawning time N. of 40° N is probably the summer half of the year especially; south of this latitude, and also in the Mediterranean, almost exclusively the winter half. Growth is far more rapid in the southern waters than farther north; maturity

(over 50 mm. total length) is attained, in the southern area and in the Mediterranean, after one year, in the northern area after two years. The females seem to carry their eggs for some considerable time, and increase in size, not inconsiderably, during the period. Larval development is unknown; the smallest known specimens (8—10 mm.) are of the same shape as the adults. Shoals may occur, but consist for the greater part always of small individuals.

Distribution.

Mediterranean, especially western basin; west coast of Europe from S. W. Norway to Gibraltar; Indian Ocean (Bay of Bengal, Red Sea); Pacific: Japan.

1. Mediterranean. On the "Thor" see above. — Villafranca, Nizza, Genova, Corsica, Isola Maddalena; Greece: Sapienza, Astros, Naxos (Carus 1885, p. 481). — Nizza (Ortmann 1891). — Messina, ?Catania (Riggio 1905). — Adriatic, in the southern deep parties (Pesta 1918, but not Adensamer 1898, see Pesta l. c. p. 64, 67). — Capri 1000—2000 m.w., and 110 m.w., closing net (daytime); between Monaco and Villafranca 2000 m.w.; on the shore at Faro (Messina); several spec. (Lo Bianco 1902, 1903 (p. 185), 1904 (p. 28, fig. 37).)

2. Atlantic. West coast of Europe from S. W. Norway to Gibraltar, but not the North Sea and the English Channel. The northern limit cannot be given with certainty; but it is at all events not found as far to the North as Lofoten (Appellöf 1906, p. 188); and it occurs scarcely at Bergen (Appellöf 1906, p. 116). On the other hand it is found at Mosterhavn N. of Stavanger (Sund 1912, p. 17). By G. O. Sars (1882, p. 49) it is given from Christianiafjord and "several localities at the West coast." Also Sund (1912, p. 17) mentions several specimens from Christianiafjord. In Skagerak are found a few specimens (K. Stephensen, 1910, p. 288), even at Bohuslän (Lagerberg 1908, p. 8—9). It is abundant W. of Scotland and is found in the Bristol Channel, S. W. Ireland, Bay of Biscay and at Portugal (see Kemp 1910, p. 38). — On the "Thor" see above. — 36°—45° N, 11° W, 50 spec. (Coutière 1911, p. 157). It is scarcely found S. of Cadiz Bay.

Adensamer (1898, p. 626) states its being mentioned from Iceland by Thomson. This must be due to an error, for the species is never found as far to the west, not even at the Færoes, and I have not been able to find the citation. Should Iceland be a misprint for Ireland?

3. Indian Ocean. Andaman Sea, 200 fms.; Bay of Bengal 200—350 fms.; several spec., one ♀ with ova, carapace 14 mm. (Alcock 1901). — Red Sea, 8 localities, taken pelagically or with dredge, 650—910 m., several spec. (Balss 1915, p. 17).

4. Pacific. Boshiu, Japan, 1 ♀ with ova, 70 mm. (Balss 1914, p. 20).

Genus Parapasiphaë Smith.

Parapasiphaë Smith 1884, p. 383.
Parapasiphæa Alcock 1901, p. 64.
Parapasiphaë Stebbing, Edinburgh 1914, p. 294.
— de Man 1920, p. 3 (list of species).

1. PARAPASIPHAË SULCATIFRONS Smith.

Parapasiphaë sulcatifrons Smith 1884, p. 384, Pl. 5 fig. 1, Pl. 6 fig. 1—7.
— — — 1886, p. 683.
— — H. J. Hansen 1908, p. 79.
— — Kemp 1910, p. 47, Pl. 5.

Atlantic.

St. 180. 2160 m. 61°31′ N, 19°05′ W. 10-7-1904. 1800 m.w. 9 spec. 16—35 mm. — **St. 183.** > 2000 m. 61°30′ N, 17°08′ W. 11-7-1904. 1800 m.w. 15 spec. 16—32 mm. (but one spec. 45 mm.). — **St. 57.** 1985 m. 57°47′ N, 11°33′ W. 7-6-1905. 1500 m.w. 1 spec. 37 mm. — **St. 62.** 2480—2775 m. 50°25′ N, 12°44′ W. 5-6-1906. 1500 m.w., 2^{45} am, 120 min. 2 spec. 29—33 mm. — **St. 74.** 1170 m. 40°23′ N, 12°13′ W. 9-6-1906. 2000 m.w., (Eel drift-seine), 1^{20} pm., 60 min. 1 spec. 33 mm. — **St. 74.** ibid. 1245—1298 m. 10-6-1906. 2000 m.w., 6^{35} am, 60 min. 7 spec. 19—29 mm. — **St. 74.** ibid. 1220 m. 9-6-1906. 2500 m.w., (Eel drift-seine), 9^{50} pm., 60 min. 2 spec., 33—35 mm. — **St. 76.** > 2600 m. 49°27′ N, 13°33′ W. 11-6-1906. 2800 m.w., 3^{00} pm., 120 min. 3 spec. 9—15 mm. — **St. 178.** > 4000 m. 48°04′ N, 12°40′ W. 2-9-1906. 1800 m.w. 9^{05} am, 120 min. 5 spec. 23—42 mm. — **St. 179.** > 4000 m. 47°20′ N, 12°23′ W. 3-9-1906. 1800 m.w., hour? 4 spec. 23—31 mm. — **St. 180.** 4000 m. 48°19′ N, 13°53′ W. 3-9-1906. 1800 m.w., 5^{05} pm., 60 min. 2 spec. 16—37 mm. — **St. 181.** 1850 m. 49°22′ N, 12°52′ W. 4-9-1906. 1800 m.w., 10^{35} am, 60 min. 3 spec. 22—40 mm. — **St. 190.** > 4000 m. 46°30′ N, 7°00′ W. 11-9-1906. 2700 m.w., 8^{25} am, 150 min. 6 spec.: 1 ♀ with ova 45 mm.; 5 spec. 18, 21, 24, 37, 55 mm. — **St. 189.** 3500 m. 47°27′ N, 7°55′ W. 10-9-1906. 1800 m.w., 0^{20} pm., 60 min. 2 spec. 10—14 mm. — **St. 65.** 1300 m. 35°53′ N, 7°21′ W. 24-2-1909. 1600 m.w., 0^{30} pm., 120 min. 1 spec. 27 mm. — **St. 69.** > 3500 m. 36°13′ N, 9°44′ W. 28-2-1909. 3000 m.w., 6^{30} pm., 60 min. 1 spec. 38 mm. — **St. 75.** > 4000 m. 45°37′ N, 7°03′ W. 9-3-1909. 4300 m.w., 1^{45} pm., 120 min. 1 spec. 65 mm.

The material contains 65 spec. from 15 st., 17 hauls.

Depths of the sea and occurrence. The depth is always > 1000 m., in half-part of the stations > 3000 m.

The stations lie between S. Iceland and the Cadiz

Bay, especially at S. W. Ireland, where it was known from several localities (Kemp 1910).

Vertical occurrence. That the species is pelagic is shown beyond doubt by the fact that the length of wire is almost always considerably less than the depth to bottom.

Depth in m.	No. of stations
0—1000	—
> 1000—2000	4
> 2000—3000	4
> 3000	7

It has only been taken with 1500—4300 m.w.: at night, 1500—3000 m.w., and by day almost exclusively with 1800—2000 m.w.

This agrees very well with the material from the "Michael Sars" (Murray & Hjort 1912, p. 668); out

M. wire	No. of hauls		
	Night	Day	Night? or day?
1500—1600.....	1	1	1
1800—2000.....	—	6	3
2500—3000.....	2	2	—
4300.....	—	1	—

of a total of 150 specimens, 125 were taken by day, and 25 at night, both night and day at a depth of 500—1500 m. below surface (at night, however, also one specimen at over 1500 m.). During the night, they seem to be evenly distributed throughout this range; in the daytime, on the other hand, there appears to be an optimum at 1000 m. The species is thus decidedly a deep-water form, which is also borne out by its appearance; colouring red (Kemp 1910, p. 49), eyes reddish crimson (Kemp 1910) or dark brown (Murray & Hjort 1912, p. 668), ova red (Murray & Hjort) and skin rather soft, this last particularly in the larger specimens.

Size and propagation. Most of the specimens are rather small, abt. 16—35 mm. Only a few are essentially larger: 45 and 55 mm. (St. 190, 1906), 65 mm. (St. 75, 1909). The largest specimens in our museum are 74 mm. (Davis Straits "Tjalfe" Exped.), 75 mm. (S. of Iceland, "Ingolf" St. 191). The largest specimen mentioned in literature is 83 mm. (one of Smith's type specimens).

Only a single ♀ was found with ova; it was 45 mm., and taken at St. 190, 11-9-1906, 2700 m.w. It had abt. 25 eggs, measuring 1.5 × 2.5 mm. This is a considerably smaller size than stated in the literature: 3 × 3.7 mm. (Kemp 1910), 4 × 5 mm. (Smith 1884) while the shape, also, is more oblong.

Distribution. America, several localities 35°12′10″—41°53′ N, 65°21′50″—74°57′15″ W, 516—2949 fms. (Smith 1884 and 1886). — Davis Straits, 4 stations 63°13′ — 64°35′ N, 900—1500 m.w., and E. of S. Greenland (1 st.) 60°07′ N, 48°26′ W, 2000 m.w., totally 22 spec. (K. Stephensen "Tjalfe" 1912). — W. and S. of Iceland, 3 st., 2160—abt. 2300 m., 1800 m.w., 25 spec. (H. J. Hansen 1908; the two stations S. of Iceland are st. 180 and 183 (1904) from the "Thor"). — S. W. Ireland, very abundant (Kemp 1910). — On the "Thor" see above. — 36°—45° N, 11° W, 7 spec. (Coutière 1911). — Cape Point E. N. E. 36 miles (Cape Colony), 660 fms. (Stebbing 1914, p. 33).

Fam. Hoplophoridæ Kingsley.

Oplophoridæ Kingsley 1878, p. 68.
Ephyrinæ Smith 1882, p. 66.
Miersiidæ — 1886, p. 667.
Acanthephyridæ Bate 1888, p. 481, 927.
Miersiidæ Stebbing 1905, p. 104 (lit. and syn.).
Hoplophoridæ Kemp 1906, p. 3.
— — 1910, p. 35, 55.
Oplophoridæ Stebbing 1910, p. 394.
Hoplophoridæ de Man 1920, p. 41 (with list of all genera and species).

From the "Thor" area, there are in all 6 genera known, with 17 (?18) species, of which the "Thor" has 5 genera with 9 species (2 as new to science, viz. *Systellaspis densispina* and *Ephyrina bifida*).

A single species, *Acanthephyra pulchra*, seems to be endemic to the Mediterranean; it was not taken by the "Thor". All the other species are found in the Atlantic (or there and in other oceans) and only 1 of these, *Acanthephyra multispina*, has also been found in the Mediterranean. There are thus in the Mediterranean only 2 species, which is doubtless due to the fact that the others, being deep-sea forms (a term which, indeed, also applies to the two Mediterranean species) cannot endure the high temperature in the deeper water layers of the Mediterranean. It is remarkable that the one species (*Systellaspis debilis*) which was most frequently taken comparatively near the surface, stops outside Gibraltar without passing in through the strait.

The depths to bottom are always very great, generally 1000 metres or over.

A single species is almost arctic (*Hymenodora glacialis*) and thus only just touches the "Thor" area (coast of Ireland). Another species, also, *Acanthephyra multispina*, occurs in at any rate very rarely S. of S.W. Ireland, and it is remarkable that this species in particular should also be met with in the Mediterranean.

The two mentioned northern species, whose European limit of occurrence, or at any rate of occurrence in any considerable numbers, lies abt. 50° N, have each a southern substitute form, closely allied to and often confused with it, viz. *Acanthephyra multispina* — *A. purpurea*, and *Hymenodora glacialis* — *H. gracilis*.

The only species which appear to be common are *Acanthephyra purpurea, A. multispina, Systellaspis debilis* and *Hymenodora glacialis*; specimens of *Acanthephyra pulchra* and *Hymenodora gracilis*, however, are also fairly numerous. The mentioned species are probably also the only ones which can occur in shoals.

Only exceptionally are these species taken as near the surface as with 300 m.w. (— *Systellaspis debilis* can, however, be taken at night with 65 m.w.) for the most part, indeed, they are taken with 1000 m.w. or more even at night, and their appearance is in accordance with this. Where the colour is known, it is always dark red (see especially Kemp 1910 under the separate species) save in a single instance, (*Hymenodora gracilis*) where it is orange. The eyes, strangely enough, seem mostly to be black, but can also be brown (*Hymenodora gracilis*) or whitish with a faint golden tinge (*H. glacialis*). The genus *Hymenodora* takes its name from the softness of its integument. A single species has luminous organs (*Systellaspis debilis*).

Although the adults, then, are bathypelagic, the larvæ can, at any rate occasionally, (*Acanthephyra multispina, A. purpurea*?) be met with comparatively near the surface, being taken, indeed, with 65 m.w. (day and night). Some have very large ova (the genera *Systellaspis* and *Hymenodora*), which suggests a very abbreviated larval development. Save in very few cases (*Acanthephyra multispina, A. purpurea, Systellaspis debilis*) nothing is otherwise known as to the larval development.

A list of all the species found in the "Thor" area is given below.

Hoplophorus Grimaldi Coutière, Comptes Rendus, Paris, 17. April 1905.
— — — 1905, p. 1—5, fig. 1,1-9.
— — Lenz u. Strunck 1914, p. 328—29, Pl. 22.
(32°18′ N, 23°58′ W, 0—2000 m., 1 spec. (Coutière). — 31°21′ S, 14°02′ W, 10 m., night, several spec. (Lenz u. Strunck).)

T.[1] *Acanthephyra purpurea* M.-Edw., see below p. 44.
T. *A. multispina* (Coutière) Sund, see below p. 44.

[1] T indicates that the species was taken by the "Thor".

A. pulchra A. Milne-Edwards, Diagnose d'un Crustacé Macroure nouveau de la Méditerranée. Acanthephyra pulchra n. sp. — Bull. Soc. Zool. France, vol. 15, 1890, p. 163.
— Prince de Monaco, Comptes Rendus Paris, tome 110, 1890, p. 1170.
— Riggio 1895, and 1896, p. 244, Pl. 1, fig. 1.
— Adensamer 1898, p. 625.
— Senna 1903, p. 296, Pl. 13.
— Kemp 1906, p. 23.
(Monaco, 1650 m., 33 spec. (Prince de Monaco 1890, Milne-Edwards 1890). — 41°24$^2/_3$′ N, 7°43$^1/_2$′ E, 2836—2809 m., 1 spec.; 39°40$^2/_3$′ N, 9°54$^1/_4$′ E, 1553 m., 1 spec.; 40°44$^2/_3$′ N, 11°22′ E, 2390—2188 m., 1 spec. (Senna 1903). — Augusta (between Catania and Siracusa) (200 m.?) (Riggio 1896). — Between Crete and Africa: 33°11$^1/_3$′ N, 22°53′ E, 1765 m.; 33°4′ N, 21°15$^2/_3$′ E, 1770 m.; 36°15′ N, 21°7′ E; 34°45′ N, 24°23′ E, 1274 m.; totally 16 spec. (Adensamer 1898; A. enumerates still one station (st. 95), but this is not to be found in his list of localities).)

A. microphthalma Smith 1885, p. 502.
- — — 1886, p. 668, Pl. 124 fig. 3.
- longidens Bate 1888, p. 735, Pl. 124 fig. 4.
- microphthalma Wood-Mason & Alcock 1891, p. 361.
- — Alcock 1901, p. 80.
- — Kemp 1906, p. 24.
(37°23′ N, 63°8′ W, 2620 fms., 2 spec.; 36°16$^1/_2$′ N, 68°21′ W, 2571 fms., 4 spec. (Smith 1885, Smith 1886). — 36°—45° N, 11° W, 1 spec. (Coutière 1911). — Bay of Bengal 1748 fms., 2 spec. (Alcock 1901, Wood-Mason & Alcock 1891). — Philippine Islands 2°55′ N, 124°53′ E, 2150 fms., 1 ♂ (Bate 1888).)

A. brevirostris Smith (nec Bate) 1885, p. 504.
- — — 1886, p. 670, Pl. 14 fig. 2, Pl. 15 fig. 2—8, Pl. 16 fig. 1, 6.
- duplex Bate 1888, p. 843, Pl. 136 fig. 3.
- brevirostris Faxon 1895, p. 167.
- — Kemp 1906, 0. 24.
(37°12′20″ N, 69°39′ W, 2949 fms., 3 spec.; 39°22′ N, 68°34′30″ W, 1683 fms., 1 spec.; 37°50′ N, 73°03′50″ W, 1395 fms., 1 spec.; 37°23′ N, 63°08′ W, 2630 fms., 1 spec. (Smith 1885, Smith 1886). — 36°—45° N, 11° W, 4 spec. (Coutière 1911). — 1°7′ N, 81°4′ W, 1 spec. (Faxon 1895). — 46°16′ S, 48°27′ E, Marion Isl., 1600 fms., 1 spec. (Bate).)

?*A. Batei* Faxon.
- brevirostris Bate 1888, p. 751, Pl. 126 fig. 5.

A. Batei Faxon 1895, p. 167.
- — H. J. Hansen 1908, p. 77, Pl. 4 fig. 2a.
- — Kemp 1906, p. 24.

(61°30′ N, 17°08′ W, 1800 m.w., 1 spec. (H. J. Hansen 1908). — 36°—45° N, 11° W, 1 spec. (Coutière 1911, p. 157; "*A. parvirostris* Bate nec Smith"; this should perhaps be a misprint for *A. brevirostris* Bate nec Smith, = *A. Batei* Faxon). — 1°22′ N, 26°36′ W, 1500 m. (Bate 1888).)

T. *Systellaspis debilis* M.-Edw., see below p. 54.
T. *S. densispina* n. sp., see below p. 57.
S. echinurus Coutière 1911, p. 158.
(36°—45° N, 11° W, 1 spec. (Coutière).)
T. *Ephyrina bifida* n. sp., see below p. 58.
E. Hoskyni Wood-Mason, see below under *E. bifida* p. 58.
T. *E. Benedicti* Smith, see below p. 59.
T. *Hymenodora glacialis* Buchh., see below p. 59.
T. *H. gracilis* Smith, see below p. 60.
H. mollis Smith.
Meningodora mollis Smith 1882, p. 74, Pl. 11 fig. 8—9, Pl. 12 fig. 5—9.
Hymenodora — Bate 1888, p. 841, Pl. 135 fig. 5.
(34°28′25″ N, 75°22′50″ W, 1632 fms., 1 ♀ (Smith 1882). — 36°—45° N, 11° W, 20 spec. (Coutière 1911, p. 157). — 8°37′ S, 34°28′ W (Pernambuco), 675 fms., 1 ♀ (Bate 1888).)

T. *Notostomus atlanticus* Lenz u. Strunck, see below p. 60.
N. elegans A. Milne-Edwards 1881, p. 8.
— — 1883, Pl. 33.
(36°—45° N, 11° W, 1 spec. (Coutière 1911, p. 157). — 24°36′ N, 84°05′ W, 955 fms. (Milne-Edwards 1881).)

Genera Acanthephyra M.-Edw. and Systellaspis Bate.

*1. *Acanthephyra* (partim) Kemp 1906, p. 3 (lit. and syn.); list of species p. 20—23, key to the species p. 23—24.
— de Man 1920, p. 43 (list of species), 53.
2. *Systellaspis* Bate 1888, p. 757.
— Coutière 1905, p. 5—7.
— de Man 1920, p. 43 (list of species), 50.

Acanthephyra was established by Milne-Edwards in 1881. Bate (1888, p. 757) separated out *Systellaspis* in order to include *S. lanceocaudata* n. sp. and the previously established *Acanthephyra debilis* M.-Edw. but this genus has not since been maintained by other writers than Coutière, de Man Sund.

For a definition of *Systellaspis* see Bate 1888, but more particularly Coutière 1905. To the generic differences noted by Coutière may perhaps be addéd the external sex difference; the species mentioned below, at any rate, exhibit some considerable difference in this respect.

The sex difference in *A. purpurea* with regard to plp. 1—plp. 2 has been mentioned already by Smith 1882 p. 69—70, which is here quoted with some few additions.

In ♂ the outer ramus in plp. 1 is like that of the succeeding pleopoda. The inner ramus is a broad oval lamella, abt. a third as long as the outer ramus, with both margins setigerous and the inner thickened end bearing a slender stylet (Smith 1882, Pl. 11 fig. 7; Coutière 1905, fig. 4, 8). The inner ramus of plp. 2 has the same shape as the outer ramus, but bears the two stylets characteristic of the male; these stylets are respectively $^1/_4$ and $^1/_2$ as long as the inner ramus.

In the ♀ the inner ramus of plp. 1 is a very small lamella, abt. $^1/_5$ as long as the outer ramus, nearly 4 times as long as broad and furnished with very long and slender setæ. In plp. 2 the inner ramus is of the same shape as the outer ramus, but a little shorter, and provided with only one stylet, abt. $^1/_5$ as long as the inner ramus.

In *A. multispina* the sex difference is as in *A. purpurea*.

In *Systellaspis debilis* the sex difference is not so strongly marked. In ♂ (Smith 1882, p. 72, Pl. 11 fig. 4b-c) the inner ramus in plp. 1 is a little more than a third as long as the slender normal outer ramus, fully three times as long as broad, ciliated along the outer edge, the inner edge straight and projecting slightly dorsally, but without a stylet as in *A. purpurea*. The inner ramus of plp. 2 bears the usual two stylets, but the secondary stylet, specially characteristic of the male, is very short, abt. $^2/_5$ as long as the outer (Smith: $^1/_5$ as long in an immature ♂, 44 mm.).

In ♀ plp. 1 is abt. as in *A. purpurea*, but the inner ramus a little longer; plp. 2 as in *A. purp.* —

Kemp 1906, p. 20—24 gives a bibliography and list of determination for all species of *A.* (incl. *Syst.*) then known. With the prolonged terminal section of the telson as an easily distinguishable character for *Systellaspis*, this genus should include *S. debilis* M.-Edw., *S. lanceocaudatus* Bate, *S. affinis* Faxon and *S. cristata* Faxon; later, *S. echinurus* Coutière (1911, p. 158) was established, and the "Thor" has taken a new species, *S. densispina*. Of the genus *Acanthephyra* sens. strict. the only one later established is *A. multispina* (Coutière) Sund, *vide infra*.

Acanthephyra purpurea M.-Edw. sens. str. and A. multispina (Coutière) Sund.

(Chart 5, fig. 15).

1. *A. purpurea* M.-Edw. sens. str.

Acanthephyra purpurea A. Milne-Edwards 1881, p. 935.
— — — 1882, p. 37.
— — — 1883, Pl. 33.
Miersia Agassizi Smith 1882, p. 67, Pl. 11 fig. 5—7, Pl. 12 fig. 1—4.
Acanthephyra— — 1884, (partim) p. 372, (not the fig.).
— *purpurea* Bate 1888, p. 733, Pl. 124 fig. 3 (teste Kemp 1906, p. 11).
— *sica* (partim) — p. 739, Pl. 125 fig. 1 (teste Kemp 1906, p. 11).
— *Agassizi* Faxon 1895, p. 161.
— *Batei* Stebbing 1905, p. 107, Pl. 24 B.
— *purpurea* Coutière 1905, p. 10 fig. 4.
— *parva paucidens* Coutière ibid. p. 15, fig. 5, 3.
— *purpurea* Coutière 1906, p. 12, fig. 5, 6, 7 A-B, 7 E.
* — — (partim) Kemp 1906, p. 4, 23 (lit. and syn.), (Pl. 2 fig. 1-3?).
— — (partim) Kemp 1910, p. 56.
* — — Murray & Hjort 1912, p. 585, 622—24, 668, 720, Pl. 3 fig. 2 (col. fig.).
— *purpureus* Stebbing 1915, p. 96.
— *purpurea* (partim) de Man 1920, p. 43.

For literature on larvæ and development see below p. 47.

2. *A. multispina* (Coutière) Sund.

Acanthephyra Agassizi Smith 1884, p. 372 (partim), Pl. 8 fig. 1 (the fig. is *A. multispina*, not *A. purpurea*).
— *sica* (partim) Bate 1888, p. 739, Pl. 125 fig. 1 (teste Kemp 1906, p. 11).
Acanthephyra acanthitelsonis Bate 1888, p. 745, Pl. 125 fig. 3.
— *purpurea* Caullery 1896, p. 375.
— *Agassizi* var. *mediterranea* Riggio 1900, p. 20.
— *rectirostris* Riggio, Mon. Zool. Ital. 1900, p. 20.
Acanthephyra rectirostris Lo Bianco 1903, p. 186.
— *purpurea* — ibid. p. 185.
— *rectirostris* Riggio 1905, p. 40, Pl. 3 fig. 1—17.
— *purpurea* var. *mediterranea* Riggio 1905, p. 35, Pl. 2 fig. 12-15, Pl. 3 fig. 18.
— *Haeckeli* Thiele 1905, p. 466.
— *rectirostris* — p. 467.
— *purpurea* var. *multispina* Coutière 1905, p. 10.
— *parva multidens* Coutière 1905, p. 15, fig. 5, 1—2.
— — — +*A. purpurea* var. *multispina* Coutière 1906, p. 18, fig. 7 C-D.
* — *purpurea* (partim) Kemp 1906, p. 4, 23 (lit. and syn.), Pl. 1, (Pl. 2 fig. 1—3?).
— — H. J. Hansen 1908, p. 75 (all the specimens from the "Ingolf" and the "Thor").
— — (almost exclusively) Kemp 1910, p. 56.
* — *multispina* Sund, in Murray & Hjort 1912, p. 585, 622—24, 668, 720, Pl. 3 fig. 1 (col. fig.).
— *purpurea* Pesta 1912, p. 995—98, 1 textfig.
— — var. *multispina* A. v. Szüts 1915, p. 433—36.
— — Pesta 1918, p. 71 (lit.), textfig. 22.
— — (partim) de Man 1920, p. 45.

For literature on larvæ and development see below p. 47.

3. *A. purpurea* M.-Edw. or *A. multispina* (Coutière) Sund?

- *Agassizi* Smith 1886, p. 667, Pl. 15 fig. 1, 6, 7, Pl. 16 fig. 2.
- *purpurea* Ortmann 1893, p. 43.

On this literature see p. 45. —

The two species are very closely related; the only sure distinctive feature seems to be that *A. purpurea* has 3—5, generally 4 pairs of dorso-lateral spines on the telson, whereas *A. multispina* has 6—11 pairs, or even more (Coutière 1905, p. 10—11). For its relation to the

other species of the genus see KEMP 1906 p. 4—16, 23, where the literature and the synonymy are dealt with.

The species *multispina* was established by COUTIÈRE in 1905 as a variety of *A. purpurea*, and by SUND 1912 as an independent species. Having thus only comparatively recently been separated from *A. purpurea*, which was established in 1881, it is not always possible to be sure from references in the literature which species is meant; from the manner in which the above lists are compiled, however, there can be no doubt but that the individuals in every case are referred to the proper species. A further explanation is given below.

Literature.

1. A. purpurea.

From MILNE-EDWARDS' description 1881—82 it cannot be seen whether it is *A. purp.* or *A. mult.*; the specific characters, on the other hand, seem clearly indicated in his figures 1883 (no copy of this work exists in this country) as representing the individual described by him in 1881—82 (teste KEMP 1906, p. 5); in any case, COUTIÈRE (1905, p. 10) refers the mentioned figure to the species with 4 pairs of spines on the telson. — *A. Agassizi* Smith 1884 includes both species.

All BATE's specimens from the "Challenger" of "*A. purpurea*" and nearly all his specimens of *A. sica* belong to the present species (KEMP 1906, p. 11.)

In the following literature, the species appears without difficulty from the separate descriptions or figures: SMITH 1882, FAXON 1895, STEBBING 1905, and all later writers.

2. A. multispina.

Some few of BATE's specimens ("Challenger" Exp.) of *A. sica* belong to the previous species (KEMP 1906, p. 11). — *A. Agassizi* SMITH 1884 comprises both species, but his figure is *A. multispina*.

LO BIANCO 1903 gives no description from which the species can be arrived at; the determination, however, is hardly doubtful, as only *A. multispina* has been found in the Mediterranean.

THIELE 1905 I have been unable to consult; but according to KEMP 1906, p. 5, there can be no doubt but that his species in the present work are correctly placed.

In the following works, the species appears with certainty from the description or figure: *A. acanthitelsonis* BATE 1888, CAULLERY 1895, RIGGIO 1900 and 1905. The same applies to all later works.

Variation etc.

From KEMP 1906, p. 12, the following characteristics are most liable to variation.

1. Proportional length of rostrum.
2. Rostral formula.
3. Presence or absence of a spine on the posterior margin of 4th abdominal segment.
4. Comparative length of the telson.
5. Number of dorso-lateral spines on telson.

1. The rostrum, which in the larva is shorter than the eye, grows longer and longer with increasing age, (COUTIÈRE 1906, p. 16—19, fig. 6 A-F, fig. 7 B-C). In specimens with total length (from point of rostrum to point of telson) 30—40 mm. for *A. purpurea*, 40—50 mm. for

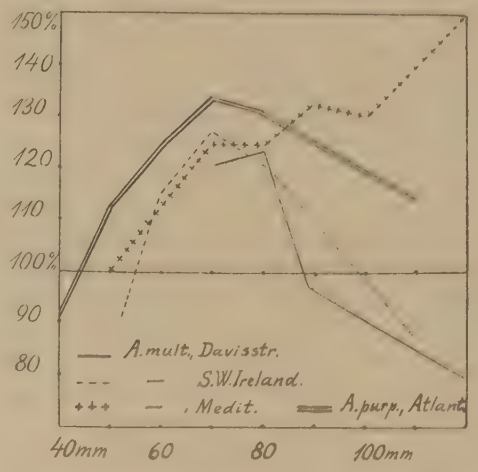

Fig. 15. Acanthephyra multispina and A. purpurea. Length of rostrum[1] in percent in proportion to the carapace (the figures 40—100 mm. indicate the total length of the body).

A. multispina, the rostrum has attained the same length as the carapace, and continues growing thenceforward, but in different degree in the two species. In order to demonstrate this growth, I have in addition to most of the specimens of *A. multispina* from the "Thor" (71 from S. W. Ireland, 40 Mediterranean) also examined 45 specimens from Davis Straits ("Tjalfe" Exp.), and 80 of *A. purpurea* from the "Thor". The result appears in the figure here given (Fig. 15).

From this it will be seen that the specimens of *A. multispina* from Davis Str. and S. W. Ireland, are almost alike: the rostrum is relatively longest in spec. of abt. 70—80 mm. (Davis Str.) or 60—70 (S. W. Ireland) then noticeably decreasing in proportion to the carapace; at a total length of 100 or 90 mm., the rostrum is equal in length to the carapace, and then decreases further in length. In the Mediterranean, the species, at

[1] measured from the eye, as shown by KEMP 1906, textfig. 1 p. 9.

a length of up to 70—80 mm. is exactly as in the Atlantic, in this respect, but instead of then decreasing in length, the rostrum here, in the larger specimens, grows longer and longer, until, in spec. of over 110 mm. we find it half as long again as the carapace itself.

Riggio (1905, p. 36) points out that two specimens from Messina should be ranked as a special variety, var. *mediterranea*, falling, in regard to the rostrum, between the typical Atlantic species (he is here mixing up *A. purp.* and *A. mult.*) and *A. sanguinea* (from the Indian Ocean) where the rostrum is somewhat longer. He does not give any further explanation of this point, but the observation is, as we see, fully confirmed by the extensive material from the "Thor".

The only description in the literature which is accompanied by measurements from the Mediterranean (13 spec.) is Szüts 1915; on reckoning from this the proportion between rostrum and carapace we arrive at exactly similar results to those above noted from the "Thor".

A. purpurea is earlier than *A. multispina* in attaining a length of rostrum equal to the carapace; (at a total length of abt. 40 mm. as against abt. 50 mm.); otherwise, up to a length of abt. 70 mm., the species appears to follow the same lines as *A. multispina*. Thereafter, the rostrum certainly decreases in size, but even in the largest specimens, it is still longer than the carapace.

2. Rostral formula.

(Teeth on the upper and under edge of rostrum).

Rostral formula	No. of specimens			
	A. multispina			A. purpurea
	Davis Str.	S.W. Ireland	Medit.	Atlantic (Bay of Cadiz)
$^{5}/_{2}$	..	..	1	—
$^{5}/_{3}$	—	..	1	—
$^{6}/_{3}$	2	..	—	1
$^{8}/_{4}$	3	..	..	—
$^{9}/_{4}$	1	2	..	—
$^{7}/_{5}$	1	3	—	1
$^{8}/_{5}$	14	27	3	21
$^{9}/_{5}$	18	24	7	14
$^{10}/_{5}$	2	7	4	1
$^{7}/_{6}$	—	—	—	1
$^{8}/_{6}$	1	5	2	8
$^{9}/_{6}$	3	5	14	26
$^{10}/_{6}$	—	7	4	4
$^{11}/_{6}$	..	—	2	—
$^{8}/_{7}$	..	..	—	1
$^{9}/_{7}$	..	..	—	1
$^{10}/_{7}$	..	..	3	—

From this it will be seen that in *A. multispina*, the rostral formula varies between $^{5}/_{2}$ and $^{10}/_{7}$. For the Atlantic, the limits lie between $^{6}/_{3}$ and $^{10}/_{6}$; it will be seen that both in Davis Str. and from S. W. Ireland the figures most frequently occurring are the same, viz. $^{8}/_{5}$ and $^{9}/_{5}$; in the Mediterranean, on the other hand the most frequent figure is $^{9}/_{6}$.

In the literature, the rostral formula for the Atlantic is given as 8—9 above, rarely 7, below 5, rarely 6, very rarely 4 (Coutière 1905, p. 11); this agrees exactly with the "Thor". Kemp 1906, p. 12, gives the formula for "*A. purpurea*" (he notes 1910, p. 57 that practically speaking, only *A. multispina* is found off the coast of Ireland) off the Irish coast as between $^{5}/_{3}$ and $^{9}/_{6}$; but he does not state which figures were the most frequent.

From the Mediterranean, we have only very few records of any service in this respect; only Pesta 1912 and Szüts have more than very few specimens (7 and 13 respectively). Of these 20 spec. 11 have $^{9}/_{6}$ rostral teeth, 4 have $^{10}/_{6}$, the remaining figures are $^{8}/_{4}$ (1 spec.) $^{9}/_{5}$ (1 spec.) $^{10}/_{5}$ (1 spec.) and $^{8}/_{6}$ (2 spec.); these figures likewise agree well with the "Thor".

For *A. purpurea*, the figures lie between $^{6}/_{3}$ and $^{9}/_{7}$; by far the most frequent, however, are $^{9}/_{6}$ and $^{8}/_{5}$, next in order $^{9}/_{5}$; the other figures are far more rarely found. According to Coutière 1905, p. 11, the figures should be the same as in *A. multispina*, which agrees very well if we take the outer limits only. Otherwise, the figures of most frequent occurrence answer to *A. multispina* in the Mediterranean, and the two next in frequency to *A. mult.* in the Atlantic.

In both species, there are as a rule 3 teeth on the upper margin inside the innermost tooth on the lower.

3. Spines on posterior margin of 4. abdominal segment are probably found in all specimens of *A. multispina*, but seem to be lacking in all specimens of *A. purpurea.*

4. Length of telson in proportion to outer ramus in urop. In *A. purpurea*, the telson is always shorter than the uropoda. The only exception I know of is that of a few specimens from the Indian Ocean, mentioned by Kemp (1913, p. 64—65) where the "telson extends noticeably beyond the uropods". As these specimens have 4—5 pairs of telson spines, there can thus after all be no doubt as to the determination.

In *A. multispina*, on the other hand, the telson should be longer than the uropoda (Coutière 1905, p. 10) this, however, is by no means always the case. In the Mediterranean, indeed, it is the exception; long telson is only found in 5 large specimens (100—120 mm.). In the Atlantic, the telson is longer than the uropoda, in a large number, abt. 30, specimens over abt. 90 mm., possibly more specimens had long telson, but a number have

the tip broken off. In all specimens of less than abt. 90 mm., the telson is equal to or shorter than the up. The long telson is thus only a specific character for specimens over 90 mm., and not even then for all. All specimens from Davis Straits on the other hand ("Tjalfe" Exp., 67—123 mm.) have long telson.

5. No. of dorso-lateral spines on the telson. Of *A. purpurea*, 3 spec. (St. 234, 1910, 300 m.w. 2 spec. and ibid. 1000 m.w. 1 spec.) have 5 pairs of spines, all the rest 4 pairs. KEMP (1906, p. 13) says that 3 pairs are found, but this is not the case with the specimens from the "Thor".

In *A. multispina*, on the other hand, the figure varies, 6—15 pairs (KEMP 1906, p. 13). Often the number is not the same on both sides; the difference may in a few rare instances amount to 2, somewhat more often 1.

A. multispina (Dorso-lateral spines on telson).

No. of spines	No. of specimens		
	Davis Str.	S.W. Ireland	Mediterr.
6— 7 [1]	..	..	3
6— 8	..	..	1
7× 2	—	—	6
7— 8	2	3	13
7— 9	2	2	—
8× 2	3	10	14
8— 9	6	14	3
8—10	1	1	—
9× 2	10	15	2
9—10	10	13	—
9—11	2	1	..
10× 2	5	15	..
11× 2	1	—	..
13× 2	—	1	..

[1] 6—7 : 6 on one side, 7 on the other, etc.

The figures, which, like the rostral formula, do not appear to depend on the size of the individual, vary between 6 on the one side, seven on the other, and 13 on both sides (in the table, this is shown as 6—7 and 13 × 2 respectively). In the Atlantic, the figures lie between 7—8 and 13 × 2. It will be seen that the figures of most frequent occurrence are not altogether the same for Davis Str. and S. W. Ireland. Of the Davis Str. specimens, most had 9 × 2 or 9—10, the Irish ones 9 × 2, 10 × 2, 8—9, 9—10 and 8 × 2; other figures very rare. In the Mediterranean, the figures are lower, lying between 6—7 and 9 × 2, mostly 7—8 and 8 × 2, but 7 × 2 is not altogether rare.

As a summary of the above, it appears that *A. multispina* from the Medinterranean differs in several respects from the Atlantic form, while in the Atlantic, there is very little difference between specimens from S. W. Ireland and those from Greenland; both forms, however, vary within certain limits, so that it is impossible to say of any given specimen whether it is from the Mediterranean or the Atlantic.

For *A. multispina*, the most important variations within the mentioned area are then as follows: In the Atlantic, the rostrum decreases in length when the individuals attain a total length of over 60—80 mm., whereas in the Medinterranean, it continues to grow, also relatively, all their life. The rostrum has somewhat fewer teeth in the Atlantic than in the Medinterranean ($^8/_5$ or $^9/_5$ as aginst $^9/_6$). In regard to the telson, on the other hand, the reverse is the case.

Development of A. purpurea and A. multispina. The youngest larvæ described (with eyes longer than the rostrum and cornea thicker than the eye-stalks) measure from eye to point of telson 5.6—13.4 mm. (KEMP 1907, p. 206—12, pl. 14). They are referred by KEMP to *A. purpurea*, but KEMP does not distinguish *A. purpurea* from *A. multisp.* and from the locality (Bay of Biscay) it cannot be determined with certainty which species it really is, though *A. multispina* would seem more likely.

A somewhat older stage, 12.9 mm. *Hoplocaricyphys similis* COUTIÈRE (1907, p. 7—10 text-fig. 1) has been ascribed by HJORT ("Naturen" 1911, p. 95) and SUND (MURRAY & HJORT 1912, p. 622) to *A. multispina*.

The post-larval, or parva-stage, is known first and foremost from the fact that the eyes are smaller in diameter than the eye-stalks. It is described by COUTIÈRE (1905, p. 15—18 text-fig. 5, *Acanthephyra parva*; 1907, p. 13—15 text-fig. 5) and KEMP (1907, p. 210—11, Pl. 14 fig. 14, 24; Pl. 15 fig. 1). It differs from the adult chiefly in the above-mentioned shape of the eye, and in the much shorter rostrum (equal in length to or somewhat shorter than the eye). The size is abt. 10.5—25 mm. This stage can, according to no. of spines on the telson, be clearly divided between the two species (COUTIÈRE 1905): *A. parva multidens* = *A. multispina*, *A. parva paucidens* = *A. purpurea*.

A brief report of the above mentioned, with some figures, is given by WILLIAMSON 1915, p. 360—61; but the two species are lumped together without any attempt at distinguishing what pertains to the separate species.

For changes taking place with age in the larger individuals, see COUTIÈRE 1906, p. 15—20, fig. 6—7 and the present work, supra, p. 45.

The parva-stage can, then, be determined as to

species, and the specimens belonging to this (they are very few) in the "Thor" material have therefore been noted in the locality lists together with older specimens of the respective species. In the case of the larvæ, on the other hand, no such determination can be made, and these are accordingly placed in a list by themselves. Nevertheless it is beyond doubt that at any rate the great bulk of the larvæ belong to *A. multispina*, since they were found in the Mediterranean, where only this species has been met with; and in the case of the larvæ from the two localities in the Atlantic, the determination, would also, from the position (S. W. of Ireland and W. of Brittany) seem to be beyond doubt, as practically speaking, only *A. multispina* has been found in these waters.

Even though the larvæ in themselves are hardly determinable, there is thus, from the localitiy, hardly room for doubt as to their being referred to the proper species. The size, (incl. rostrum) is 9—15 mm., and they agree entirely with the description given by KEMP (1907).

1. ACANTHEPHYRA PURPUREA M.-Edw. sens. str.

Literature see p. 44, 45; morphological characters and variation see p. 45; development and larvæ see p. 47.

Atlantic.

St. 76. > 2600 m. 49°27′ N, 13°33′ W. 11-6-1906. 2800 m.w., 9^{45} pm., 1 ♂ 85 mm. — **St. 74.** 1220 m. 49°23′ N, 12°13′ W. 9-6-1906. 9^{50} pm., 2500 m.w. 1 ♂ 95 mm. — **St. 65.** 1300 m. 35°53′ N, 7°26′ W. 24-2-1909. 1600 m.w., 0^{30} pm., 120 min. 46 spec.: 14—26 mm. (31 spec.), 28—31 mm. (4 spec.), 35—39 mm. (4 spec.), 2 ♂ 43—51 mm. 5 ♀ 41, 43 (2 spec.), 46, 54 mm. — **St. 69.** > 3500 m. 36°13′ N, 9°44′ W. 28-2-1909. 600 m.w., 9^{00} pm., 60 min. 28 spec.: 13 ♂: 39, 45, 60 (3 spec.), 65, 70, 72, 81, 83, 85 (2 spec.), 97 mm.; 9 ♀ without ova 37, 43, 55 (? mm.; rostrum lost), 67, 85, 87 (2 spec.), 90, 91 mm.; 6 ♀ with ova 75 (2 spec.), 82, 83 (2 spec.), 89 mm. (the eyes are visible in most of the ova). — **St. 69.** ibid. 3000 m.w., 6^{30} pm., (y. 330), 60 min. 10 spec.: 1 parva-st. 21 mm., 1 jun. 25 mm., 3 ♂ 40, 90, 91 mm.; 5 ♀ 39, 58, 78, > 83 mm. (apex of rostrum lost; ♀ with ova), 97 mm. — **St. 71.** 1150 m. 39°35′ N, 9°45′ W. 4-3-1909. 600 m.w., 6^{35} pm., 120 min. 20 spec.: 6 ♂ 77, 80 (2 spec.), 87, 91, 105 mm. 14 ♀ 36, 50, 61, 68 (3 spec.), 69, 73, 74, 75, 78, 79, 86, 87 mm. (the last one with ova). — **St. 71.** ibid. 1600 m.w., 4^{00} pm., 120 min. 12 spec.: 4 sex indet. 28 mm. (2 spec.), 32, 41 mm.; 5 ♂ 55, 63, 71, 83 mm. (2 spec.); 3 ♀ 41 mm. (2 spec.), 71 mm. (♀ with ova; the eyes are visible). — **St. 80.** > 4000 m. 46°17′ N, 7°31′ W. 15-6-1910. 300 m.w., 10^{05} pm., 30 min. 5 spec.: 2 ♂ 61, 68 mm.; 3 ♀ 49, 53, 60 mm. — **St. 91.** 1225 m. 35°53′ N, 7°26′ W. 18-6-1910. 1600 m.w., 5^{25} pm., 60 min. 13 spec.: 3 parva-st. 12, 16, 16 mm.; 3 ♂ 35, 37, 39 mm.; 5 ♀ 30, 34, 47, 74 mm. (2 spec.); 2 spec. jun. 24—29 mm. — **St. 231.** 1000 m. 35°50′ N, 7°16′ W. 9-9-1910. 300 m.w., 1^{15} am, 30 min. 5 spec.: 3 jun. 28, 29 mm. (2 spec.); 1 ♂ 63 mm.; 1 ♀ 35 mm. — **St. 231.** ibid. 1200 m.w., 2^{15} am, 30 min. 4 spec.: 2 ♂ 43—51 mm., 2 ♀ 45—83 mm. (the greater one with ova). — **St. 232.** 3700 m. 36°28′ N, 9°00′ W. 9-9-1910. 300 m.w., 10^{35} pm., 30 min. 2 ♀ 67—76 mm. — **St. 232.** ibid. 1000 m.w., 10^{35} pm., 30 min. 3 spec.: 1 ♂ 43 mm., 2 ♀ with ova 76—88 mm. — **St. 232.** ibid. 2000 m.w., 11^{45} pm., 30 min. 4 spec.: 3 ♂ 57, 68, 79 mm.; 1 ♀ with ova 79 mm. — **St. 234.** 920 m. 38°10′ N, 9°20′ W. 10-9-1910. 300 m.w., 10^{30} pm., 30 min. 6 spec.: 1 ♂ 55 mm. 5 ♀: 45, 50, 67 (with ova), 76, 87 mm. (with ova). — **St. 234.** ibid. 1000 m.w., 11^{20} pm., 30 min. 8 spec.: 1 jun. 38 mm.; 2 ♂ 48—58 min.; 5 ♀ 67, 70, 75, 79, 98 mm. (the three last with ova).

The material contains 169 spec. (46 ♂, 58 ♀, 65 spec. < 45 mm.), from 10 stations, 16 hauls.

Depth of sea and occurrence. Chart 5, p. 51). The depth to bottom is 920—over 4000 m.

Depth in m.	No. of stations
0—1000	2
> 1000—2000	4
> 2000—3000	1
> 3000	3

Two stations lie S.W. of Ireland, 1 in the Bay of Biscay, 7 between the Strait of Gibraltar and 40° N. Only 3 st. (1906, st. 74 and 76; 1909, st. 69) are common to this and *A. multispina*.

From this, then, it is seen that the species has a more southerly distribution than *A. multispina*, which was not met with in the "Thor" area south of the Bay of Biscay; this result also agrees very well with KEMP 1910, according to which only *A. multispina* is at all generally found off W. S. Ireland, very rarely *A. purpurea*.

The species has never been met with in the Mediterranean.

M. w.	Night			
	Specimens	Hauls	Duration of hauls in hours	Specimens per hour
300	18	3	2	9
600	48	2	3	16
1000—1200	15	3	1.5	10
2000—3000	16	3	?	?
	Day			
1600	81	3	5	16.2

Vertical occurrence. It has never been taken nearer the surface than 300 m.w. and as it was never taken in night hauls with lengths of line between 1200 and 2000 m.w., the yield of the deeper hauls was possibly captured during hauling in.

At night, we have nearly as many specimens per hour with 300 and with 1000—1200 m.w., considerably

more with 600 m.w., which, strangely enough, gave about the same number as day hauls with 1600 m.w., the only depth at which the species was taken during the day.

The "Michael Sars" expedition (Murray & Hjort 1912, p. 622—24, 668) has 437 specimens of the species, 195 taken by day at a depth of 100—1500 m., and 242 at night from the same depths (also 8 specimens, however, from deeper than 1500 m.). Nearly all the day specimens, (viz. 179 out of a total of 195) were taken in water layers between 500 and 1000 m. below the surface, which agrees well with the "Thor". At night, on the other hand the "Michael Sars" has the greater proportion of spec. (102) at 150 m. depth, far fewer in the other water layers, which does not agree so well with the "Thor".

The "Thor" material thus agrees with what is stated by Murray & Hjort l. c., that the species in the Atlantic lives higher up than *A. multispina*, whose maximum both day and night ("Thor") lies about 1500—1900 m.w.; the site of this maximum, however, is not the same in both expeditions.

The individuals of the different size groups do not seem to prefer any particular depth during winter within the above mentioned limits; the position is more definite in summer, where the material, small though it is, appears to show that the smaller specimens are found nearer the surface than the large ones. Females with ova do not seem to prefer any particular depth, but were found at all depths where the species was taken at all.

Shoals may occur, the greatest no. in a single haul (60 min.) is 28 specimens. In contrast to *A. multispina*, the shoals may be formed by comparatively large individuals, not essentially by the small ones; one haul of 120 minutes duration, however, yielding 46 specimens, has mostly small specimens, (31 measuring only 14—26 m.).

Size, propagation etc. Of the specimens examined as to sex, (size over abt. 45 mm.) there were 46 ♂, 58 ♀ (for sex differences see supra p. 43) the ♀ are thus somewhat more numerous than the ♂.

Size of ♂ up to 95 mm., only two are larger, the largest 105 mm. At what size the ♂ attains maturity cannot be stated, none were found with spermatophores, as was the case with *A. multispina*.

The ♀ is somewhat smaller, especially up to 90 mm., only three were larger (up to 98 mm.). The largest ♀ without ova was 97 mm. The 17 ♀ with ova measured 67—90 mm.; only one larger (98 mm.).

Females with ova were found at all depths and at the following seasons: 28. Feb., 4. April, 9.—10. Sept. i.e. not at midsummer; this, however, may be accidental.

Distribution. Disregarding the literature where *A. purpurea* cannot be distinguished from *A. multispina*, (these localities will be dealt with later on, p. 54) the distribution can be stated as follows: In the Mediterranean, it has never been found. The northern limit in the Atlantic lies, on the American side abt. 41° N, on the European abt. 40° N, very rarely farther north (up to 50° N). S. of 40° N, it thus takes the place of *A. multispina*, which is most numerous north of that limit. Many specimens were taken between 40° N and the equator. South of the equator, only few specimens have been taken, only between the point of S. Africa and abt. 25°—35° S. In the Indian Ocean, 3 stations between the southern extremity of India proper and Madagascar. In the Pacific, 3 finds in New Zealand waters, 1 S. of Japan, and 2 S. of Panama.

A specified list of localities is given below.

1. Atlantic. 41°23′15″ N, 65°51′25″ W, 810 fms.; 33°19′ N, 76°12′30″ W, 457 fms.; 31°41′ N, 74°35′ W, 1047 fms. (Smith 1882, p. 67). — *A. Agassizi* Smith 1884 comprises both *A. purpurea* and *A. multispina* ("telson . . . armed with five to twelve pairs of stout dorsal aculei . . ."); the specimens were taken at 27 localities 30°22′50″—42°02′ N, 68°16′—74°37′15″ W, 389—2949 fms. — 437 spec. between New Foundland and W. Europe, without special localities (Murray & Hjort 1912, p. 668). — S. W. Ireland, a few spec. (Kemp 1910, p. 57). — 34°51′ N, 68°30′ W, 2675 fms.; 32°41′ N, 36°6′ W, 1675 fms.; 25°49′ N, 20°12′ W, 1675 fms. (*A. purpurea* Bate 1888, p. 733, teste Kemp 1906, p. 11). — 36°46′ N, 26°41′ W, 0—3250 m.; 37°08′ N, 28°28½′ W, 0—1000 and 0—1500 m.; 35°44′ N, 11°52′ W, 0—1000 m.; 32°18′ N, 23°58′ W, 0—2000 m.; 31°46′ N, 25°00′ W, 0—3000 m.; 31°06′ N, 24°06¾′ W, 0—5000 m.; 30°41′ N, 17°46′ W, 0—2500 m.; 27° 43′ N, 18°28′ W, 0—3000 m. (Coutière 1905, p. 10). — 28°42′ N, 34°33′ W, 3000 m.; 20°41′ N, 31°53′ W, 3000 m.; 17°28′ N, 29°42′ W, 3000 m.; 5°27′ N, 21°41′ W, 1500 m.; 0°46′ N, 18°59′ W, 3000 m.; 0°6′ S, 18°18′ W, 800 m.; 24°55′ S, 1°14′ W, 1500 m.; 32°8′ S, 8°28′ W, 1000 m., night; 35°10′ S, 2°33′ E, 3000 m.; 35°39′ S, 8°16′ E, 3000 m. ("*Acanth. purpurea*" Lenz u. Strunck 1914, p. 326—27). Most of these spec. are *A. purp.* sens. str., but a few (from what localities?) are *A. multispina* ("telson . . . mit vier bis fünf, selten mit sechs Stachelpaaren besetzt"). — Cape Point Lighthouse (Cape State), S. 83° E, distant 35½ miles, from a depth of 658 m. (*A. Batei*, Stebbing 1905). — Cape Point N. E. by E. ¼ E. 40 miles, 800—900 fms. 1 spec. (Stebbing 1915).

2. Indian Ocean. 4°16′ S, 71°53′ E, 1200—0 fms.; 10°27′ S, 51°17′ E, 1000—0 fms.; 4 miles N. W. of Desroche's Atoll (Amirante), 750—0 fms. (Kemp 1907).

3. Pacific. S. of Japan 26°29′ N, 137°57′ E, Off New Zealand 40°28′ S, 177°43′ E, and 37°34′ S, 179°22′ E; Kermandec Isl. 29°45′ S, 178°11′ W (*A. sica* Bate 1888, p. 739, teste Kemp 1906, p. 11). — S. of Panama 7°21′ N, 79°2′ W, 1832 fms., and 1°7′ N, 80°21′ W, 1573 fms. (Faxon 1895).

2. ACANTHEPHYRA MULTISPINA (Coutière) Sund.

Literature see p. 44; morphological characters and variation p. 45; development and larvæ p. 47.

Non-larval stages:

Mediterranean.

St. 13. > 1200 m. 39°43′ N, 17°30′ E. 19-12-1908. 1000 m.w., 60 min., 2^{15} pm. 1 ♂ 81 mm. — **St. 24.** > 3700 m. 40°14′ N, 12°23′ E. 16-1-1909. 300 m.w., 30 min., 9^{10} pm., 1 ♂ 63 mm. — **St. 24.** ibid. 1600 m.w., 30 min., 11^{15} pm., 2 spec. 16—23 mm. — **St. 29.** 1530 m. 40°47′ N, 12°59′ E. 20-1-1909. 1650 m.w., 2^{15} pm., 60 min. 3 spec.: 18—21 mm.; 1 ♀ 96 mm. — **St. 31.** 1420 m. 41°44′ N, 10°52′ E. 22-1-1909. 1400 m.w., 1^{20} am, 60 min. 1 ♂ 98 mm. — **St. 31.** ibid. 600 m.w., 3^{05} am, 30 min. 1 (♀?) 46 mm. — **St. 35.** >2000 m. 43°36′ N, 7°36′ E. 29-1-1909, 1000 m.w., 11^{25} pm., 120 min. 1 spec. 39 mm. — **St. 35.** ibid. 1600 m.w., 11^{25} am, 120 min. 1 jun. 31 mm., 1 ♀ 53 mm. — **St. 45.** 2150 m. 37°28′ N, 8°18′ E. 6-2-1909. 300 m.w., 11^{25} pm., 30 min. 3 spec.: 1 jun. 31 mm., 1 ♀ 40 mm., 1 ♂ 56 mm. — **St. 46.** 1930 m. 37°17′ N, 6°00′ E. 7-2-1909. 65 m.w., 8^{25} pm., 30 min. 1 jun. 28 min. — **St. 46.** ibid. 600 m.w., 6^{25} pm., 30 min. 1 ♀ 107 mm. — **St. 50.** > 2000 m. 37°02′ N, 1°17′ E. 17-2-1909. 1600 m.w., 5^{30} am, 60 min. 2 ♀ 95—112 mm.; the greater one has ova in which the eyes are visible. — **St. 53.** > 2000 m. 36°13′ N, 1°28′ W. 18-2-1909. 2600 m.w. (Y. 330), 5^{15} pm., 90 min. 3 ♂ with spermatophores 104 mm. (?, telson lost), abt. 120, > 112 mm.; 1 ♂ 96 mm. (?, telson broken). — **St. 51.** > 2000 m. 36°27′ N, 0°37′ W. 18-2-1909. 300 m.w., 0^{50} am, 30 min. 1 ♀ 53 mm. — **St. 106.** 1150 m. 36°33′ N, 2°00′ W. 25-6-1910. 1200 m.w., 0^{20} am, 60 min. 1 ♂ 53 mm. — **St. 107.** > 2000 m. 36°12′ N, 1°28′ W. 26-6-1910. 2000 m.w., 7^{30} am., 60 min. 1 ♂ 88 mm. — **St. 108.** 2435 m. 36°03′ N, 0°27′ W. 26-6-1910. 2000 m.w., 0^{40} am, 60 min. 2 spec. 15—24 mm. — **St. 112.** 2700 m. 36°56′ N, 2°15′ E. 27-6-1910. 300 m.w., 0^{15} am, 30 min. 3 spec.: 1 jun. 28 mm., 2 ♀ 56—63 mm. — **St. 113.** 815 m. 36°53′ N, 3°09′ E. 28-6-1910. 300 m.w., 3^{25} am, 30 min. 3 spec.: 2 ♂ 62—74 mm., 1 ♀ 65 mm. — **St. 115.** 2800 m. 38°17′ N, 4°11′ E. 29-6-1910. 300 m.w., 11^{20} pm., 30 min. 3 spec.: 44—46 mm. — **St. 115.** ibid. 2000 m.w., 0^{30} am, 60 min. 6 spec.: 5 jun. 15, 21, 27, 29, 32 mm.; 1 ♂ 90 mm. — **St. 116.** 2860 m. 39°27′ N, 5°26′ E. 30-6-1910. 300 m.w., 1^{40} am, 30 min. 1 spec. 43 mm. — **St. 118.** > 2700 m. 41°00′ N, 6°43′ E. 30-6-1910. 300 m.w., 10^{50} pm., 30 min. 2 spec. (♂, ♀) 56 mm. — **St. 120.** 2700 m. 42°31′ N, 7°41′ E. 1-7-1910. 300 m.w., 8^{50} pm., 30 min. 1 ♀ 76 mm. — **St. 122.** 1285 m. 43°50′ N, 8°54′ E. 2-7-1910. 1200 m.w., 5^{30} am, 30 min. 4 spec.: 3 ♂ 54, abt. 80, 93 mm.; 1 ♀ with ova 117 mm.

St. 129. 3420 m. 40°05′ N, 11°31′ E. 12-7-1910. 600 m.w., 8^{00} pm., 30 min. 1 ♀ 82 mm. — **St. 143.** 1842 m. 35°18′ N, 16°25′ E. 23-7-1910. 1000 m.w., 2^{00} am, 60 min. 3 ♂ 73, 80, 95 mm. — **St. 160.** > 1000 m. 35°59′ N, 28°14′ E. 1-8-1910. 300 m.w., 2^{45} am, 30 min. 1 ♀ 50 mm. — **St. 160.** ibid. 1000 m.w., 3^{35} am, 60 min. 2 ♀ 69—88 mm. — **St. 206.** 2182 m. 39°32′ N, 5°15′ E. 28-8-1910. 1000 m.w., 1^{40} am, 45 min. 2 ♂ 103—112 mm. — **St. 209.** > 2000 m. 40°34′ N, 3°05′ E. 29-8-1910. 2000 m.w., 7^{25} am, 45 min. 2 spec. 24—32 mm. — **St. 218.** 2147 m. 36°54′ N, 2°57′ E. 2-9-1910. 300 m.w., 2^{45} am, 30 min. 1 ♂ 55 mm.

Atlantic.

St. 104. 1950 m. 62°47′ N, 15°05′ W. 24-5-1904. 1500 m.w. 1 ♀ 62 mm. — **St. 152.** 1240 m. 65°00′ N, 28°10′ W. 19-7-1904. 800 & 1000 m.w., 1 ♀ 61 mm., 1 ♂ 81 mm. — **St. 180.** 2160 m. 61°34′ N, 19°05′ W. 10-7-1904. 1800 m.w. 2 jun. 30—39 mm.; 1 ♀ 68 mm., 1 ♂ 72 mm. — **St. 183.** 61°30′ N, 17°18′ W. 11-7-1904. 1900 m.w. 8 spec. 31—35 mm. — **St. 71.** 1985 m. 57°47′ N, 11°33′ W. 7-6-1905. 1500 m.w. 2 jun. 28—33 mm.; 1 ♂ 46 mm., 1 ♀ 109 mm. — **St. 72.** 1020 m. 57°52′ N, 9°55′ W. 8-6-1905. 1500 m.w. 2 ♀ 78—89 mm. — **St. 88.** 600—993 m. 48°09′ N, 8°30′ W. 20-6-1905. 300 m.w., 8^{45} pm., 120 min. 11 spec.: 4 ♂: 48, 50, 55, 76 mm.; 7 ♀: 50, 52, 53 (3 spec.), 59 mm. (2 spec.) — **St. 90.** 740—1600 m. 47°47′ N, 8°00′ W. 21 (22)-6-1905. 300 m.w., 2^{15} am., 120 min. 8 spec.: 3 ♂ 54, 56, 57 mm.; 5 ♀: 50 (2 spec.), 52, 54, 76 mm. — **St. 36.** 1125—1050 m. 44°21′ N, 2°37′ W. 10-5-1906. 1250 m.w., 5^{55} am, 120 min. 5 ♀ 69, 80, 82, 84, 95 mm. — **St. 62.** 2480—2775 m. 50°25′ N, 12°44′ W. 5-6-1906. 1500 m.w., 2^{45} am, 120 min. 30 spec.: 25, 28, 30—33 (8 spec.), 34, 35 (4 spec.), 43 (2 spec.), 47 mm.; 7 ♂: 68, 73, 77, 79 (2 spec.), 89, 107 mm.; 5 ♀ 55, 78, 79, 81, 83 mm. — **St. 63.** 2140 m. 49°27′ N, 13°22′ W. 5-6-1906. 300 m.w. (Y. 330), 5^{30} pm., 120 min. 1 ♀ 103 mm. — **St. 74.** 1245—1298 m. 49°23′ N, 12°13′ W. 10-6-1906. 2000 m.w. (Y. 330), 6^{35} am, 60 min. 7 spec.: 29, 32, 34, 36, 39, 44 mm.; 1 ♀ abt. 83 mm. (rostrum broken). — **St. 74.** ibid. 1170 m. 2000 m.w. (Eel drift-seine), 1^{30} pm., 60 min. 5 spec.: 1 ♂ 81 mm.; 4 ♀: 84, 101, 105, 110 mm. (?, apex of telson lost).

St. 74. ibid. 1220 m. 2500 m.w. (Eel drift-seine), 9^{50} pm., 60 min. 4 spec.: 2 ♂ 79—abt. 90 mm. (?, apex of telson lost); 2 ♀ 58—96 mm. — **St. 75.** 1520 m. 49°20′ N, 12°39′ W. 10-6-1906. 2800 m.w. (Eel drift-seine), hour? 2 ♂: > 90 mm. (apex of telson lost), 96 mm. — **St. 76.** > 2600 m. 49°27′ N, 13°33′ W. 11-6-1906. 2800 m.w., 3^{00} pm., 120 min. 10 spec.: 33 (2 spec.), 34, 41, 42, 48 mm.; 1 ♂: 76 mm., 3 ♀: 97, 105, 106 mm. — **St. 80.** 1140 m. 51°34′ N, 11°50′ W. 16-6-1906. 1200 m.w. 6^{30} pm., 120 min. 9 spec.: 39, 40, 42, 45 mm.; 2 ♂: 77—80 mm.; 3 ♀: 54, 84, 95 mm. (the last one with ova). — **St. 178.** > 4000 m. 48°04′ N, 12°40′ W. 2-9-1906. 1800 m.w., 9^{05} am., 120 min. 17 spec.: 30, 31, 33 (2 spec.), 37 (2 spec.); 39—41 (4 spec.), 42, 44, 46, 49 mm.; 1 ♂ 57 mm., 2 ♀ 87—88 mm. — **St. 179.** > 4000 m. 47°20′ N, 13°23′ W. 3-9-1906. 1800 m.w. 3^{40} am., 120 min. 3 spec.: 1 jun. 43 mm., 1 ♂ 106 m., 1 ♀ 110 mm. — **St. 180.** > 4000 m. 48°19′ N, 13°53′ W. 3-9-1906. 1800 m.w., 5^{05} pm., 60 min. 6 spec.: 38 (2 spec.), 39, 45, 46, 47 mm. — **St. 181.** 1350 m. 49°22′ N, 12°52′ W. 4-9-1906. 1800 m.w., 10^{35} am., 60 min. 9 spec.:

14, 15, 16, 18, 41, 43 mm.; 3 ♀ 51, 57 mm. (2 spec.). — **St. 190.** > 4000 m. 46°30′ N, 7°00′ W. 11-9-1906. 2700 m.w., 8^{25} am., 150 min. 6 spec.: 3 ♂ 48, 92, 105 mm.; 3 ♀ 54, 88, 110 mm. — **St. 69.** > 3500 m. 36°13′ N, 9°44′ W. 28-2-1909. 3000 m.w., 6^{30} pm., 60 min. 1 ♀ with ova (the eyes are visible) > 104 mm. (apex of rostrum lost). — **St. 75.** > 4000 m. 45°37′ N, 7°03′ W. 9-3-1909. 300 mw., 7^{45} pm., 60 min. 1 ♀ 80 mm. — **St. 75.** ibid. 600 m.w., 6^{30} pm., 60 min. 5 spec.: 1 ♂ 70 mm.; 4 ♀: 68, 83, 86, 93 mm. (the last one with ova). — **St. 75.** ibid. 4300 m.w., 1^{45} pm., 120 min. 7 spec.: 4 ♂: 62, 90, 100, abt. 110 mm. (rostrum lost); 3 ♀: 64, 95, 117 mm. (the 2 last with ova). — **St. 240.** 2500 m. 44°34′ N, 8°16′ W. 15-9-1910. 1000 m.w., 9^{40} pm., 30 min. 1 ♂ 65 mm., 1 ♀ 57 mm. — **St. 242.** 4941 m. 46°19′ N, 6°48′ W. 16-9-1910. 4350 m.w., 7^{00} pm., 60 min. 1 ♀ 94 mm.

Larvæ (on determination see above p. 47):

Mediterranean.

St. 58. 85 m. 36°36′ N, 4°24′ W. 20-2-1909. 65 m.w., 3^{00} pm., 30 min. 3 larvæ 9, 12, 12 mm. — **St. 107.** > 2000 m. 36°13′ N, 1°28′ W. 25-6-1910. 300 m.w., 9^{05} pm., 30 min. 3 larvæ 12, 12, 15 mm. — **St. 108.** > 2435 m. 36°03′ N, 0°27′ W. 26-6-1910. 2000 m.w., 0^{40} am., 60 min. 1 larva 11 mm. — **St. 113.** 815 m. 36°53′ N, 3°09′ E. 28-6-1910. 300 m.w., 3^{25} am. 30 min. 2 larvæ 15 mm. — **St. 115.** 2800 m. 38°17′ N, 4°11′ E. 29-6-1910. 2000 m.w., 0^{30} am., 60 min. 2 larvæ 12—15 mm. — **St. 118.** > 2700 m. 41°00′ N, 6°43′ E. 30-6-1910. 65 m.w., 11^{35} pm., 30 min. 1 larva 10 mm. — **St. 118.** ibid. 300 m.w., 5^{55} pm., 30 min. 5 larvæ 11, 15, 15, 15, 15 mm. — **St. 129.** 3420 m. 40°05′ N, 11°31′ E. 12-7-1910. 300 m.w., 3^{40} am., 30 min. 1 larva 14 mm. — **St. 132.** 1227 m. 38°57′ N, 9°47′ E. 14-7-1910. 600 m.w., 4^{50} am., 30 min. 2 larvæ 6—14 mm. — **St. 133.** 600 m. 38°18′ N, 9°59′ E. 14-7-1910. 300 m.w., 10^{15} pm., 30 min. 2 larvæ 10—15 mm. — **St. 133.** ibid. 600 m.w., 9^{30} pm., 30 min. 1 larva 14 mm. — **St. 137.** 175—195 m. 37°17′ N, 10°56′ E. 19-7-1910. 250 m.w., 9^{05} am., 30 min. 1 larva 14 mm. — **St. 143.** 1842 m. 35°18′ N, 16°25′ E. 23-7-1910. 300 m.w., 0^{30} am., 30 min. 1 larva 15 mm. — **St. 199.** 2700 m. 39°32′ N, 10° 49′ E. 28-8-1910. 300 m.w., 9^{25} pm., 20 min. 1 larva 12 mm. — **St. 199.** ibid. 1000 m.w., 10^{10} pm., 30 min. 1 larva 13 mm. — **St. 206.** 2782 m. 39°32′ N, 5°15′ E. 28-8-1910. 300 m.w., 1^{05} am., 15 min. 2 larvæ 12—15 mm. — **St. 210.** 775 m. 41°10′ N, 2°23′ E. 30-8-1910. 600 m.w., 3^{35} am., 30 min. 1 larva 14 mm.

Atlantic.

St. 88. 600—995 m. 48°09′ N, 8°30′ W. 20-6-1905. 300 m.w. 8^{45} pm., 240 min. 11 larvæ 10—15 mm. — **St. 66.** > 4000 m. 48° 43′ N, 15°17′ W. 6-6-1906. 400 m.w., 2^{15} pm., 60 min. 3 larvæ 15 mm.

The material comprises 277 spec. (55 ♂, 72 ♀, 106 spec. (non larvæ) < abt. 50 mm., 44 larvæ (determination see p. 47), from 57 stations, 72 hauls.

A. Mediterranean.

The material contains 63 spec. (23 ♂, 14 ♀, 26 spec. < 50 mm.), from 26 stations, 32 hauls. Besides the "Thor" has taken 30 larvæ (see above p. 51) from 14 st., 17 hauls; at 8 of these 14 stations also non-larvæ were taken.

Depths of the sea and occurrence. (Chart 5).

The depth to bottom is very great, especially 1000-3000 m. The non-larval stages have only one station less than 1000 m. (viz. 815 m.). The larvæ can, on the other hand, be met with at very much shallower places, which agrees with the fact of their keeping closer to the surface: 5 stations showed a depth to bottom of less than 1000 m., viz. 85, 175—195, 600, 775 and 815 m.

Depths in m.	No. of stations	
	Non-larvæ	Larvæ
0— 500.....	—	2
> 500—1000.....	1	3
> 1000—2000.....	8	2
> 2000—3000.....	15	7
> 3000.....	2	1

The stations lie more or less evenly distributed throughout the western basin; only 3 lie in the eastern, and one of them even east of Crete. Larvæ were only found at 1 station in the eastern basin (St. 143, S. E. of Sicily).

Such information as the literature affords with regard to distribution in the Mediterranean is given below. In some cases it cannot be seen whether *A. purpurea* or

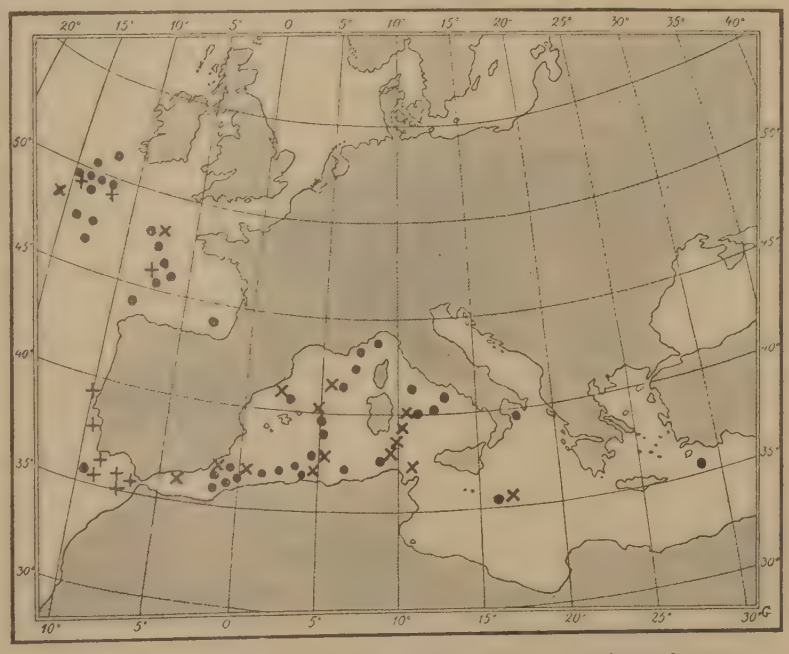

Chart 5. Acanthephyra. • A. multispina, adult or postembryonal stages. ×| same species, larvæ. + A. purpurea.

A. multispina is meant (Lo Bianco 1903, Pesta 1918); but since the true *A. purpurea* has never been recorded from the Mediterranean, there can be no doubt that all records from this water refer to *A. multispina*. In all other cases it is evident that *A. multispina* is really meant.

42°53′ N, 8°22′ E, 0—2000 m. (*A. purp.* var. *mult.*, Coutière 1905, p. 10). — Between Capo Corso and Monaco, 2000 m.w. (*A. purp.*); Capri 2400 m.w., 1 spec., and Salina, Eolian Isl., 2500 m.w., 1 spec. (*A. rectirostris*?, Lo Bianco 1903, p. 185—86). — Messina (*A. purp.* var. *medit.*, 2 spec.; *A. rectirostris*, 4 spec.; Riggio 1900 and 1905). — Messina, 1 spec. and 48°8.7′ N, 17°40.6′ E (Adria), 600—900 m., 7 spec. ("*A. purp.*", Pesta 1912, p. 995—98). — S. Adria (*A. purp.*, Pesta 1918). — Pelagosa-Gravosa (Adria), 300—1100 m., 18 spec. (*A. purp.* var. *mult.*, Szüts 1915, p. 433—36).

Vertical occurrence.

M. w.	Non-larvæ				Larvæ			
	Night		Day		Night		Day	
	Hauls	Spec.	Hauls	Spec.	Hauls	Spec.	Hauls	Spec.
65	1	1	—	—	1	1	1	3
200—300	11	20	—	—	6	9	3	9
600	3	3	—	—	3	4	—	—
1000—1200	6	13	1	1	1	1	—	—
1400—2600	5	13	5	12	2	3	—	—
total	26	50	6	13	13	18	4	12

There appears to be no difference between summer and winter.

Only 3 specimens (2 larvæ, 1 spec. of 28 mm.) were taken with 65 m.w. (night and day); the other non-larval stages were never found nearer the surface at night than with 300 m.w., and by day considerably deeper (over 1000 m.w.). The greatest length of line was 2600 m.w., the most frequent depth (night) seems to be 300—1200 m.w.

It will be seen that the larvæ prefer the upper water layers both day and night, especially 250—300 m.w., the other individuals, however, do not appear to show any preference for a particular depth within the limits noted, as was the case in the Atlantic (*vide infra*).

Shoals do not occur; the max. of specimens taken in a single haul was 6.

Size and propagation etc. For sex differences *vide supra*. p. 43.

Of specimens over 50 mm., there are only 23 ♂, 14 ♀. Both sexes grow to about the same size, 120 mm. (♂) and 117 (♀), and similarly, we find in the different size groups approximately equal nos. of either sex.

Ova were found only in the two largest ♀, 112 and 117 mm.; all the others lacking ova. The two ♀ with ova were taken on the 18. Feb. and 2. July; it would seem then, as if the species propagated all the year round. Three ♂ with spermatophores outside the genital apertures were found (St. 53, 18-2-1909, 2600 m.w.); the sizes of the specimens were 104—120 mm. Larvæ were found both winter and summer, though certainly more numerous in summer; this, however, is doubtless due here to the fact that we had most stations at that season.

B. Atlantic.

	Stations	Hauls	Specimens (non-larvæ)		
			♂	♀	< 50 mm.
May 1904	1	1	—	1	—
July —	3	3	2	2	10
June 1905	4	4	5	11	8
May 1906	1	1	—	5	—
June —	6	8	15	19	34
Sept. —	5	5	4	9	28
Feb. 1909	1	1	—	1	—
Mar. —	1	3	5	8	—
Sept. 1910	2	2	1	2	—
total	24	28	32	58	80

The material contains 170 spec. (non-larvæ) (32 ♂, 58 ♀, 80 spec. < abt. 50 mm.) from 24 st., 28 hauls, and 14 larvæ from 2 st., 2 hauls.

Depth of the sea and occurrence. The depth is nearly always over 1000 m.; only 1 st. is of slighter depth (600—993 m.) and at this one, both larvæ and older individuals were found.

All stations lie between S.W. Ireland and the base of the Bay of Biscay. Only three stations are common to this and *A. purpurea* (1906, st. 74 and 76, 1909, st. 69).

Non-larval stages	
Depth in m.	No. of stations[1]
500—1000	1
> 1000—2000	10
> 2000—3000	5
> 3000	7

[1] The depth was at a single station (st. 183, 1904) not noted.

Vertical occurrence.

M. w.	Non-larval stages								
	Night				Day				Night? or Day? No. of hauls
	Hauls	Spec.	Duration of hauls in hours	No. of spec. pr. hour	Hauls	Spec.	Duration of hauls in hours	No. of spec. pr. hour	
300— 400	3	20	5	4	1	1	2	0.5	—
500— 800	1	5	1	5	—	—	—	—	1
1000—1200	3	16	4.5	3.6	—	—	—	—	—
1500—1900	2	33	4	8.3	3	32	4	8	5
> 1900	3	6	3	2	5	35	8.5	4.1	1

Larvæ occur only relatively near the surface, but were only taken in two hauls, 300 m.w. night, 400 m.w., day. They may, however, be met with even nearer the surface: 50 fms. (KEMP 1910, p. 57) otherwise, the depth according to the literature is more especially 50—150 m. (MURRAY & HJORT 1912, p. 622—24), 0—100 fms. (KEMP 1907, p. 211).

The parva stage, on the other hand, lives much deeper down. The "Thor" has only 5 specimens, taken both day and night with 1500—1900 m.w., i. e. at same depth as the older ones. According to the literature, this stage occurs at 500—400 fms. and 750—500 fms. (KEMP 1907, p. 211) and 800—465 fms. (KEMP 1910, p. 57—58).

The older stages were taken at night in 12 hauls, 300 to over 1900 m.w. relatively greatest no. per hour with 1500—1900 m.w. In the daytime, it was taken practically speaking only with over 1500 m.w., relatively most frequent with 1500—1900 m.w.

According to MURRAY & HJORT (1912, p. 668) the "Michael Sars" took in all 232 spec. in the Atlantic, 209 by day and 23 at night, in both cases only at a depth of 500—1500 m. By day it was most numerous at a depth of 1000—1500 m. which agrees well with the "Thor" but at the same time, the "Thor" results show that the species can occur much nearer the surface.

The collections mentioned by KEMP 1910 from S. W. Ireland show (by day?) a similar but somewhat slighter depth than the "Thor" and the "Michael Sars"; save for a single haul with 50 fms. w. especially 500—700 fms. w. There seems to be, according to the "Thor", a slight tendency among the older specimens to keep lowest of all; one spec. of 103 mm., however, was taken by day with only 300 m.w. (St. 63, 1906).

Shoals can occur, but are not frequently met with; by far the greatest no. in one haul (120 min.) was 30. When more than a very few specimens are taken in one haul, most of them are nearly always small, under abt. 50 mm., of the largest specimens, only a few are ever found in each haul.

Size and propagation. Of specimens over 50 mm., there were 32 ♂, 58 ♀.

Size of both sexes about the same, up to 110 mm. (a single ♀ however, 117 mm.) but in the higher size-groups (over 80 mm.) there are relatively somewhat more ♀ than ♂ (31 and 12 respectively) considering that the material contains nearly twice as many ♀ as ♂.

Only 5 females with ova in all (sizes: 93, 95, 95, over 104, 117 mm.) taken a night with 600, 1200 and 3000 m.w., and by day with 4300 m.w. Dates: 28. Feb., 9. March and 16. July (KEMP 1910, p. 7 gives only Feb.).

Only 3 ♂ had spermatophores outside the genital aperture. Sizes, 81, 92 and 105 mm.; taken 9. June and 11. Sept. with 2000 and 2700 m.w. We have, however, in our museum, from the "Tjalfe" exped. (S. W. Greenland) out of a total of 31 ♂, no fewer than 20 with spermatophores; sizes, 90—121 mm., length of wire 1500—2000 m.w.

Distribution. Disregarding the literature where it cannot be seen whether this species or *A. purpurea* is meant, (these localities will be treated later on, p. 54) the distribution may be given as follows: 1. Mediterranean; western basin especially. 2. Atlantic. The northern limit here lies about Davis Str. (abt. 64° N), W., S.W. and S. of Iceland and S. W. of the Færoes. On the American side it has been taken at a few places abt. 40° N; on the European side the southern limit of great frequency lies in the Bay of Biscay (very numerous off S.W. Ireland). Roughly speaking, then, we can note it as most numerous between 64° and 40° N; south of this limit it can occur, at any rate as far as the equator, possibly even in the southern part of the Atlantic (abt. 25°—40° S) but this is uncertain. It seems then to take the place of *A. purpurea* N. of abt. 40° N. 3. In the Pacific it has been found at two places, S. of Australia and off the coast of New Zealand. In the Indian Ocean it has never been found.

Specified list of localities is given below.

1. Mediterranean, see above p. 51—52.

2. Atlantic. All the specimens from the "Ingolf"-Exped., mentioned by H. J. HANSEN 1908 as *A. purpurea*, are in reality *A. multispina*; the localities are Davis Straits 63°30′ N (1 st.), W., S. W. and S. of Iceland (5 st.). — S. W. Greenland, 4 localities 60°07′—64°06′ N, 1185—2000 m.w. (*A. purpurea*, K. STEPHENSEN "Tjalfe" 1912). — 41°10′ N, 66°2′ W, 1259 fms., WANDEL leg., 1 spec. (in our Zool. Mus.). — Martha's Vineyard 39°12′ N, 72°3½′ W, 707 fms., 2 spec. (U. S. Fish. Comm. st. 2235, in our Zool. Mus.). — *A. Agassizi* SMITH 1884 comprises both *A. purpurea* and *A. multispina*; see *A. purpurea* p. 45. — 232 spec.; 500—1500 m. below surf., between New Foundland and Europe (no special localities; MURRAY & HJORT 1912, p. 668). S. W. Ireland, very common (KEMP 1910). — 44°39′ N, 4°30′ W, 800 m.w., 3 spec. (*A. purpurea*, CAULLERY 1896). — Bay of Biscay 0—100 fms., 1 ♂ ad 81 mm. (KEMP 1907). — 46°15′ N, 7°09′ W, 0—3000 m.; 47°36′ N, 7°38′ W, 1490 m.; 36°17′ N, 28°53′ W, 0—3000 m.; 32°18′ N, 23°58′ W, 0—2000 m. (COUTIÈRE 1905). — 1°47′ N, 24°26′ W, 1850 fms., 1 ♂, trawled; 1°22′ N, 26°36′ W, 1500 fms., 1 ♂, trawled (*A. acanthitelsonis* BATE 1888). — 0°46′ N,

18°59′ W, 3000 m., several spec. (*A. purp.* var. *acanthitelsonis*, Lenz & Strunck 1914; also some of their localities for "*A. purpurea*", see *A. purpurea* p. 49).

3. Pacific. 40°28′ S, 177°43′ E, 1100 fms., 1 spec., trawled, bottom temp. 37.2° F; 47°25′ S, 130°22′ E, 2150 fms., 2 ♂, trawled, bottom temp. 34.5° F. (*A. sica* Bate 1888, teste Kemp 1906, p. 11).

Acanthephyra purpurea or A. multispina (se above p. 44).

(References to literature from which the species cannot be determined.).

1. Atlantic. 36°16½′—39°46½′ N, 68°21′—73°09′ W, 578—2574 fms., 26 spec. from 19 localities (Smith 1886, *A. Agassizi*). — Abt. 10° N, 22° W, 0—400 m., 1 ♀, and abt. 6° N, 20° W, 4000 m., trawl, 1 ♀ (*A. purp.*, Ortmann 1893). — 36°—45° N, 11° W, 100 spec. (Coutière 1911, *A. purp.*). — N. of Falkland Isl. 42°32′ S, 56°29′ W, 1 spec. (*A. sica*, Bate 1888, teste Kemp 1906, p. 11; telson broken).

2. Pacific. Between Australia and Salomon Isl., 1 spec. (*A. sica*, Bate 1888, teste Kemp 1906, p. 11; telson broken).

3. SYSTELLASPIS DEBILIS M.-Edw. (Chart 6, fig. 16).

Acanthephyra debilis A. Milne-Edwards 1881, p. 13.
— — — 1883, Pl. 33, fig. 2.
Miersia gracilis Smith 1882, p. 70, Pl. 11 fig. 4.
Systellaspis debilis + *S. Bouvieri* Coutière 1905, p. 5 fig. 2, p. 8 fig. 3.
**Acanthephyra* — Kemp 1906, p. 16 (lit. and syn.), p. 23, Pl. 2 fig. 4—7.
Systellaspis — Coutière 1906, p. 1—12, fig. 1—4.
Acanthephyra gracilis H. J. Hansen 1908, p. 76.
— *debilis* Kemp 1910, p. 59, Pl. 6 fig. 1—15.
Systellaspis Murray & Hjort 1912, p. 668, Pl. 3 fig. 3 (cold. fig.).
Acanthephyra — Williamson 1915, p. 358, figs. 35—38 (development).
Systellaspis var. *indica* de Man 1920, p. 51, Pl. 6 figs. 11—11 f. (with lit.).

Atlantic.

St. 81. 960—1420 m. 51°32′ N, 12°03′ W, 13(14)-6-1905. 300 m.w., 7^{35} am., 120 min. 2 spec.: 29—35 mm. — **St. 88.** 600—995 m. 48°09′ N, 8°30′ W. 20-6-1905. 300 m.w., 8^{45} pm., 120 min. 4 spec.: 28 (2 spec.), 30, 31 mm. — **St. 90.** 740—1600 m. 47°47′ N, 8°00′ W. 21(22)-6-1905. 300 m.w., 2^{15} am., 120 min. 1 ♀ 67 mm. — **St. 90.** 1012—830 m. ibid. 500 m.w., 7^{30} pm., 120 min., 5 spec.: 19 (2 spec.), 23, 29, 35(?) mm. — **St. 93.** 1230—1350 m. 49°25′ N, 12°20′ W. 24-6-1905. 300 m.w., 3^{30} pm., 60 min. 6 spec.: 22, 38, 43 mm.; 1 ♂ 58 mm.; 2 ♀ 52—68 mm. — **St. 93.** ibid. 200 m.w., 1^{15} am., 120 min. 2 ♀ 43—53 mm. — **St. 36.** 1140 m. 44°21′ N, 2°31′ W. 10-5-1906. 300 m.w., 2^{55} am., 120 min. 2 ♂ 48—58 mm. — **St. 36.** ibid. 1035 m. 800 m.w., 9^{05} am., 120 min. 22 spec.: 15 jun.: 16, 21, 25—27 (4 spec.), 32 (2 spec.), 38, 40, 41 (2 spec.), 43, 45, 50(?) mm.; 2 ♀: 56—68 mm., 5 ♂: 60, 66, 70, 71, 80 mm. — **St. 36.** ibid. 1250 m.w., 5^{55} am., 120 min. 3 spec.: 40, 44, 48 mm. — **St. 46.** 1360 m. 44°37′ N, 2°17′ W. 17-5-1906. 300 m.w., 1^{45} am., 120 min. 6 spec.: 3 jun.: 18, 24, 39 mm.; 3 ♂: 57, 65, 74 mm. — **St. 52.** 1860—1910 m. 48°42′ N, 12°20′ W. 21-5-1906. 300 m.w., 0^{25} am., 120 min. 1 ♂ 56 mm. — **St. 62.** 2480—2775 m. 50°25′ N, 12°44′ W. 5-6-1906. 1500 m.w., 2^{45} am., 120 min. 1 spec. 28 mm. — **St. 67.** 4000 m. 48°29′ N, 14°15′ W. 7-6-1906. 1700 m.w. 5^{00} am., 120 min. 1 ♂(?) 50 mm., 1 ♂ 70 mm. — **St. 75.** 1520 m. 49°20′ N, 12°39′ W. 11-6-1906. 800 m.w., 1^{50} am., 120 min. 1 ♂ 81 mm., 1 ♀ with ova 81 mm. — **St. 75.** ibid. 1500 m.w., 4^{30} am., 120 min. 1 ♂ 80 mm. — **St. 76.** > 2600 m. 49°27′ N, 13°33′ W. 11-6-1906. 2800 m.w., hour?. 1 jun. 21 mm. — **St. 88.** 1880 m. 55°05′ N, 12°20′ W. 23-6-1906. 300 m.w., 120 min. 1 ♀ 59 mm. — **St. 89.** 1600 m. 55°45′ N, 9°35′ W. 23-6-1906. 200 m.w., 120 min. 1 ♀(?) 48 mm. — **St. 176.** 1125 m. 49°31′ N, 11°51′ W. 31-8-1906. 300 m.w., 120 min., 9^{30} pm. 5 spec.: 3 ♂: 75, 78, 83 mm., 1 ♀(?) 50 mm, 1 ♀ with ova 78 mm. — **St. 178.** > 3000 m. 48°04′ N, 12°40′ W. 2-9-1906. 300 m.w., 120 min., 3^{15} am. 16 spec.: 2 spec. 40 mm., 5 ♂: 52, 56, 61, 72—80 mm., 9 ♀: 50, 53, 54, 61, 68 (2 spec.), 73, 75 mm. (2 spec., with ova). — **St. 178.** ibid. 1800 m.w., 9^{05} am., 120 min. 1 spec. 33 mm. — **St. 179.** > 4000 m. 47°20′ N, 13°23′ W. 3-9-1906. 1800 m.w., 120 min., 3^{40} am., 8 spec.: 2 spec. 35—47 mm., 2 ♂: 53—58 mm., 4 ♀: 49, 53, 60, 61 mm. — **St. 180.** > 4000 m. 48°19′ N, 13°53′ W. 3-9-1906. 1800 m.w., 60 min., 5^{05} pm. 15 spec.: 22 (2 spec.), 32, 35 (2 spec.), 40 (2 spec.), 43, 45 (2 spec.), 2 ♂: 55—58 mm., 3 ♀: 59 (2 spec.) 65 mm. — **St. 181.** 1350 m. 49°22′ N, 12°52′ W. 4-9-1906. 1800 m.w., 60 min., 10^{30} am. 1 spec. 37 mm. — **St. 182.** 2200 m. 50°11′ N, 12°05′ W. 4-9-1906. 600 m.w., 60 min., 6^{45} pm. 1 ♀ 61 mm. — **St. 190.** > 4000 m. 46°30′ N, 7°00′ W. 11-9-1906. 300 m.w., 120 min., 3^{00} am. 6 spec.: 3 ♂: 65, 67, 75 mm.; 3 ♀: 73 (2 spec.), 75 mm. (with ova; rostrum abnormous, only 10 mm.). — **St. 65.** 1300 m. 35°53′ N, 7°26′ W. 24-2-1909. 1600 m.w., 0^{30} pm., 120 min. 6 spec.: 3 spec. 35, 42, 46 mm., 2 ♂: 53—85 mm., 1 ♀ with ova 77 mm. — **St. 66.** 735 m. 36°16′ N, 6°52′ W. 25-2-1909. 300 m.w., 2^{55} am., 120 min. 50 spec.: 18, 22, 25, 30 mm. (3 spec.), 33, 35 mm. (3 spec.), 37 mm. (2 spec.), 39 mm. (4 spec.), 41, 43 mm. (3 spec.), 46, 48—49 mm. (4 spec.); 14 ♂: 53—63 mm; 13 ♀: 3 ♀ 50—53 mm., 9 ♀ 57—65 mm. — **St. 66.** ibid. 600 m.w., 5^{15} am., 120 min. 41 spec.: 17—23 mm. (7 spec.), 26—29 (4 spec.), 31—34 (8 spec.), 35—39 (13 spec.), 43—49 (6 spec.); 3 ♂: 55, 58, 63 mm. — **St. 69.** > 3500 m. 36°13′ N, 7°48′ W. 28-2-1909. 300 m.w., 11^{40} pm., 30 min. 1 spec. 25 mm. — **St. 69.** ibid. 600 m.w., 9^{00} pm., 60 min. 1 ♂ 70 mm., 1 ♀ 62 mm. — **St. 69.** ibid. 3000 m.w., 6^{30} pm., 60 min. 1 spec. 32 mm. — **St. 71.** 1150 m. 39°35′ N, 9°45′ W. 4-3-1909. 300 m.w., 8^{40} pm., 120 min. 31 spec.: 20 ♂: 51, 56, 58 (5 spec.), 60 (3 spec.), 61, 63, 65 (4 spec.), 66, 67, 70, 77 mm.; 11 ♀: 44, 48, 50, 57 (2 spec.), 59, 62 (3 spec.), 66 (2 spec.). — **St. 71.** ibid. 600 m.w., 6^{25} pm., 120 min. 43 spec.: 22 spec. 16—21 mm.; 7 ♂: 52, 56, 59, 68, 69, 73 mm. (2 spec.); 14 ♀: 4 without ova 63 (3 spec.), 68 mm., 10 with ova: 75 (2 spec.), 78—81 (7 spec.), 87 mm. — **St. 71.** ibid. 1600 m.w.,

4^{00} pm., 120 min. 5 spec.: 3 ♂: 61, 62, 73 mm.; 2 ♀ with ova 71—76 mm. — **St. 75.** > 4000 m. 45°37′ N, 7°03′ W. 9-3-1909. 300 m.w., 7^{45} pm., 60 min. 1 ♂ 54 mm. — **St. 75.** ibid. 600 m.w., 6^{30} pm., 60 min. 5 spec.: 2 spec. 29—31 mm., 2 ♂ 65—75 mm., 1 ♀ 54 mm.— **St. 75.** ibid. 4300 m.w. (Y. 330), 1^{45} pm., 120 min. 1 ♂ 71 mm. — **St. 76.** 1800 m. 47°01′ N, 5°48′ W. 10-3-1909. 1600 m.w., 2^{40} pm., 60 min. 1 spec. 13 mm. — **St. 80.** > 4000 m. 46°17′ N, 7°31′ W. 13-6-1910. 300 m.w., 10^{45} pm., 30 min. 1 ♂ 68 mm. — **St. 81.** 2140 m. 41°32′ N, 9°32′ W. 15-6-1910. 300 m.w., 4^{00} pm., 30 min. 20 spec.: 22 (5 spec.), 27 (3 spec.), 28—30 (9 spec.), 34, 37 mm. (2 spec.). — **St. 89.** 1310 m. 36°28′ N, 8°22′ W. 1000 m.w., 4^{10} am., 30 min. 8 spec.: 24, 28 (2 spec.), 29, 38 (2 spec.), 44, 47 mm. — **St. 89.** ibid. 1800 m.w., hour? 1 spec. 17 mm. — **St. 91.** 1225 m. 35°53′ N, 7°26′ W. 18-6-1910. 1600 m.w., 5^{25} pm., 60 min. 19 spec.: 14—17 (4 spec.), 20, 38, 39, 40, 41, 42 mm., 5 ♂: 62, 64, 66, 69, 70 mm.; 4 ♀: 3 without ova 48, 58, 62 mm.; 1 with ova 72 mm. — **St. 231.** > 950 m. 35°50′ N, 7°16′ W. 9-9-1910. 300 m.w., 1^{15} am., 30 min. 8 spec.: 3 spec. 22, 41, 46 mm.; 1 ♂ 70 mm.; 4 ♀: 1 without ova 53 mm., 3 with ova 64 mm. — **St. 231.** ibid. 1200 m.w., 2^{15} am., 30 min. 2 spec.: 1 ♂ 63 mm., 1 ♀(?) 46 mm. — **St. 232.** 3700 m. 36°28′ N, 9°00′ W. 9-9-1910. 300 m.w., 10^{35} pm., 30 min. 3 ♀ with ova 71, 80, 87 mm. — **St. 232.** ibid. 2000 m.w., 11^{45} pm., 30 min. 2 spec.: 1 spec. 38 mm., 1 ♀ with ova 77 mm. — **St. 234.** 920 m. 38°10′ N, 9°20′ W. 10-9-1910. 300 m.w., 10^{30} pm., 30 min. 19 spec.: 7 ♂: 54, 56, 61, 64 (2 spec.), 66 mm. (2 spec.); 5 ♀: 36, 46, 50, 56, 60 mm.; 7 ♀ with ova: 66, 68, 70, 72 (2 spec.), 73, 76 mm. — **St. 234.** ibid. 1000 m.w., 11^{20} pm., 30 min. 2 ♀ with ova: 66—73 mm. — **St. 240.** 2500 m. 44°34′ N, 8°16′ W. 15-9-1910. 300 m.w., 9^{00} pm., 15 min. 5 spec.: 30, 37, 39, 45; 74 mm (♂). — **St. 240.** ibid. 1000 m.w., 9^{40} pm., 30 min. 1 spec. 20 mm. — **St. 245.** 330 m. 47°14′ N, 6°02′ W. 17-9-1910. 65 m.w., 9^{55} pm., 15 min. 3 spec.: 40, 47, 62 mm (♂). — **St. 245.** ibid. 400 m.w., 5^{15} pm., 120 min. 38 spec.: 6 jun. 37, 40 (2 spec.), 45, 46, 50 mm.; 21 ♂: 58, 60, 64 (2 spec.), 69 (5 spec.), 71, 73, 75 (3 spec.), 82 (5 spec.), 85, 87 mm.; 11 ♀: 8 without ova 53, 57, 61, 64 (2 spec.), 65, 74, 83 mm., 3 with ova 75, 79 mm (2 spec.).

On the development see Coutière 1905 and 1906 and Williamson; on the eyes: especially Coutière 1906; on the luminous organs: Coutière 1906 and Kemp 1905 (1906) and 1908 (1910).

Atlantic.

The material contains 398 spec. (117 ♂, 98 ♀, 183 jun. [< abt. 50 mm.]), from 35 stations, 54 hauls, all situated in the Atlantic between W. Ireland and the Bay of Cadiz. The species is not known from the Mediterranean.

	No. of stations	No. of hauls	No. of specimens ♂	♀	jun. (< abt. 50 mm.)
June 1905	4	6	—	5	14
May 1906	3	5	11	2	21
June —	6	7	4	3	2
Aug. —	1	1	3	2	—
Sept. —	6	7	9	20	19
Feb. 1909	3	6	20	15	46
Mar. —	3	7	32	18	25
June 1910	4	5	6	4	30
Sept. —	5	10	32	29	17
total...	35	54	117	98	183

Depths of the sea and occurrence (Chart 6). Only one st. has a depth of 330 m.; the other > 500 m., most of them > 1000 m. All these stations are situated from W. Ireland to the Bay of Cadiz, several in the Bay of Biscay. The species was known from all these seas except from the Bay of Cadiz (see below under Distribution).

Depths in m.	No. of stations
330	1
500—1000	5
> 1000—2000	16
> 2000—3000	5
> 3000	8
total...	35

Vertical occurrence.

M. w.	Night: No. of hauls	No. of specimens	Duration in hours	No. pr. hour	No. of hauls: Day	Day? or Night?
65	1	3	1/4	12	—	—
200.....	1	2	2	1	—	1
300— 400..	17	160	24 3/4	6.5	4	1
500— 800..	7	99	11	9	1	—
1000—1250..	5	16	4	4	—	—
1400—2000..	5	14	6 1/2	2.1	7	1
2800—4000..	1	1	1	1	1	1
total...	37				13	4

At night, there were most hauls with 300 m.w., but highest average of spec. per haul with 500—800 m.w. The nos. of individuals decrease upward and down; the fact that the only haul with 65 m.w. (duration 15 min.) yielded 3 spec. i. e. 12 per hour must doubtless be accidental.

In the daytime, it was taken especially with 1400—2000 m.w., but there are 4 hauls with 300—400 m.w. not taken nearer the surface than this. (Both Kemp 1908 (1910) and Murray & Hjort (Depths of the Ocean 1912, p. 668) however, note a few specimens taken by day quite close to the surface; so also Kemp 1907).

Chart 6. Systellaspis debilis. Positive stations.

On endeavouring to separate out the hauls according to season, geographical area (N. or S. of 40° N) and size of specimens, it was found that the species keeps to the same depth at all seasons and throughout the whole area, while the individuals are evenly distributed between the limits noted, without regard to size.

Murray & Hjort l. c. p. 668 record 264 spec. taken by the "Michael Sars" exped., 170 at night, 94 by day. At night, 57 spec. were taken at a depth of 100 m., 74 at 150 m.; the "Thor" maximum, then, lies somewhat deeper. In the day time, the "Michael Sars" took 16 spec. at 150 m, 20 at 300 and 29 at 500 m. depth; the remaining specimens were distributed, a few in each depth.

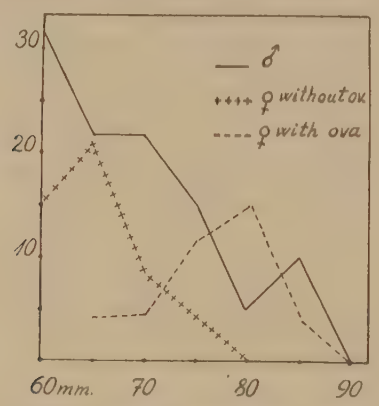

Fig. 16. Sizes of Systellaspis debilis.

Shoals can occur, though each haul as a rule only contains a few specimens; hauls of a couple of hours' duration, however, may bring up 41—50 spec. The large numbers are almost always chiefly composed of small specimens; of large ones, each haul has generally only a few.

Size and propagation. For sex difference in the pleopoda *vide supra* p. 43. Another method of determing sex is to examine a triangular process situate on the ventral side behind the 5. pair of legs, with its point turned forward; in the male, it is about as long as broad, reaching only to the posterior margin or at the outside, to face the middle of the genital aperture (which last, by the way, is not always easily discernible) or abt. $^1/_6$—$^1/_8$ of the distance to p. 4. In the ♀ on the other hand, the progress in question is nearly six times as long as it is broad at the base, and can reach as far as p. 4.

Of specimens determined as to sex (over abt. 50 mm.) there were somewhat more ♂ than ♀, 117 and 98 respectively.

Taking the specimens over 55 mm., we have altogether 104 ♂ and 87 ♀ (50 without ova, 37 with). The largest individuals of both sexes are 87 mm. (1 ♂, 2 ♀) (Fig. 16). Male and female then grow to equal size, though there are somewhat more ♂ than ♀ over 80 mm. It will be seen that nearly all the largest ♀ have ova, which suggests either that they only spawn once, or that they do not grow to any degree after the first spawning.

The female attains maturity at a smaller size than the male; in some few specimens (54, 58, 60, 63, 63, 70 mm.; St. 93, 1905, 300 m.w.; st. 36 1906) 800 m.w., st. 66, 1909, 300 m.w., st. 231 1910, 1200 m.w., a couple of spermatophores are discernible outside the genital aperture. In a considerable number of specimens of like size, the spermatophores can be seen through the skin, situate inside the vas deferens.

South of 40° N, at any rate, females with ova have been found at nearly all seasons when the species was taken at all; we have 30 ♀ from Feb., March, June and Sept. North of 40° N, 70 ♀ with ova were found in those months in which collections were made; June, August, September. Females with ova are evenly distributed throughout the water layers where the species is found.

Distribution.

1. Atlantic. Especially N. Atlantic from S. Iceland to Bahama Islands and Canarian Islands. — S. of Iceland 62°47′ N, 15°03′ W, 1950 m., 1500 m.w. (H. J. Hansen 1908). — 36°5$^1/_2$′ N, 69°51$^3/_4$′ W, 2512 fms, 1 ♀ ovig. (Smith 1885 [1887]). — 34°28′25″ N, 75°22′50″ W, 1632 fms, 1 spec. (Smith 1882). — Bahama Channel, 500 fms. (Milne-Edwards 1881). — Old Bahama Channel, 428 fms., 1 spec. (Faxon, Bull. Mus. Comp. Zool. vol. 30, 1896, p. 163). — N. Atlantic, 264 spec. (Murray & Hjort 1912). — W. and S. W. Ireland, several spec. (Kemp 1905 [1906] and 1908 [1910]). — Bay of Biscay, surf. — 25 m., 1 ♂ 67 mm. (Kemp 1907). — 36°46′ N, 26°41′ W, 0—3250 m., 3 spec. (Coutière 1905). — 39°26′ N, 42°40′ W, 0—2000 m.; 38°04′ N, 26°07$^1/_2$′ W, 0—3000 m.; 37°17′ N, 19°10′ W, 0—3000 m.; 33°41′ N, 36°55′ W, 0—3000 m.; 33°07′ N, 15°49′ W, 0—1000 m.; 31°42′ N, 42°40′ W, 0—2000 m.; 31°38′30″ N, 42°38′ W, 0—2000 m. (Coutière 1906). — 36°—45° N, 11° W, 200 spec. (Coutière, 1911, p. 157). — 28°42′ N, 34°33′ W, 3000 m.; 17°28′ N, 29°42′ W, 3000 m.; 35°39′ S, 8°16′ W, 3000 m. (Lenz u. Strunck, 1914, p. 327).

2. Pacific. Kauai Islands (Hawaiian Isl.), 478—453 fms., 1 spec. (Rathbun 1906, p. 922).

4. SYSTELLASPIS DENSISPINA n. sp. (Fig. 17).

St. 190. > 4000 m. 46°30′ N, 7°00′ W. 11-9-1906. 2700 m.w., 8^{25} am, 150 min. 1 ♀ 89 mm.

Rostrum abt. 8 mm. (the outermost apex is lost), carapace without rostrum 19 mm. (measured as shown by KEMP 1906, textfig. 1).

Carapace somewhat compressed, not carinate dorsally. Rostrum $^2/_5$ as long as the carapace, straight, triangular seen from the side, laterally compressed, continued on the carapace with a carina somewhat shorter than the rostrum itself. The outermost apex is lost. On the dorsal edge 11 teeth, of which 4 on the carapace; ventrally 3 teeth. The branchiostegal spine prominent, directed forward and a little outward; it has a little, blunt carina. The eyes are not much wider than the eye-stalks, pyriform, with a rather great tubercle at the inner (median) side. The eye-colour is black.

Antennal scale is a little more than $^2/_3$ as long as the carapace (13.5 to 19 mm.), 4 times as long as broad, with a little apical spine.

An exopod at all the pereiopoda. P. 3—p. 4 of equal length, abt. $1^1/_2$ time as long as p. 5; when stretched forward they pass the apex of the antennal scale.

The median angle of the antero-lateral margin of epimeral parts of the first abdominal segment is blunt, of the same shape as in *S. debilis* (KEMP 1906, Pl. 2 fig. 4).

No dorsal carina on the abdomen except on the third segment which has a long stout dorsal spine. 4.—5th segments have a very little dorsal spine, but no such is found in the 6th segment. The form of the hind edge of the epimeral parts of these segments may be seen from my fig., note especially the incision and tooth at the lower hind edge of segment 5. Segment 6 is twice as long as segm. 5 (respectively 15 and 8 mm.).

The telson is a trifle longer than 6th segment, 17 mm. It has about the same form as in *S. debilis* (KEMP 1906, Pl. 2 fig. 7), but is somewhat more slender. The apex is tongue-shaped with 8—9 spines at each side; the outer most part is damaged. Laterally of the base of the apex are a pair of spines, half as long as the apex. The distal two thirds of the telson are densely trimmed with spines in two rows (— from this the specific name *densispina* —): the one at the ventral edge, the other row a little more dorsally. Between the spines in the lower row some fine setæ may be seen.

Outer ramus of the uropoda is of abt. the same length as the telson, inner ramus somewhat shorter.

On colour or luminous organs no information can be given.

Affinities. In the shape of the rostrum, it resembles at a first glance *A. curtirostris*, but is easily distinguished from this species inter alia by the long p. 3—p. 4 (in *A. curt.* equal in length to p. 5) by the much longer spine on 3. abdominal segment and the close arrangement of spines on the telson (*A. curt.* has 9—10 pairs of sub-marginal spines + 5 pairs of somewhat longer apical spines) as also by the fact that the telson terminates in a tongue-shaped end section.

This species is perhaps identical with *S. echinurus* COUTIÈRE (1911, p. 158) but the description of this latter

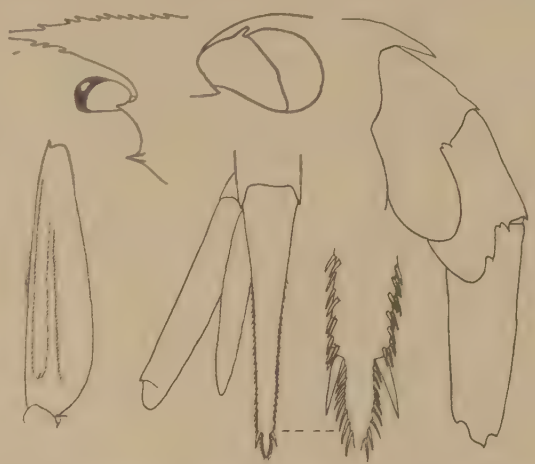

Fig. 17. Systellaspis densispina. Rostrum, eye (the right one, seen partly from the dorsal side, partly from the lateral side), antennal plate, the last abdominal segments, and caudal fan.

is so brief that there are in reality only two specific characters (the others are generic characters) viz. "son rostre est court" and the specific name "*echinurus*" which, however, is not justified by the text. Both these characters would, it is true, apply to the "Thor" spec. while the locality also is the same, (36°—45° N, 11° W); this is, however, too slight a foundation to warrant out classing them as identical.

That it belongs to the genus *Systellaspis*, not *Acanthephyra*, is altogether beyond doubt, especially from the large, tongue-shaped terminal section of the telson.

Genus Ephyrina Smith.

Ephyrina Smith 1885, p. 68.
Tropiocaris (partim) Bate 1888, p. 834.
Ephyrina Alcock 1901, p. 83.

Of the genus *Ephyrina*, only 2 species are hitherto known, and these two are closely allied: *E. Hoskyni* WOOD-MASON, and *E. Benedicti* SMITH, both described

and figured by KEMP 1910, p. 68—72, Pl. 7, where also the literature is noted. They are chiefly distinguished one from the other by the shape of the rostrum, and by the lack (*E. Hoskyni*) or presence (*E. Benedicti*) of a spine on the 3. caudal segment. These characters, however, seem to apply only to large specimens, over abt. 50 mm. KEMP 1910, describes a small specimen, 24 mm., which he refers to *E. Benedicti* from the rostrum, but it lacks the tooth on the 3. caudal segment; KEMP considers that the lack of this tooth is due to the youth of the specimen.

This genus is represented in the "Thor" material by 3 small specimens of *E. Benedicti*, besides a large specimen which is certainly nearly related to the two known species, but should nevertheless probably be taken as the type of a new species.

1. EPHYRINA BIFIDA n. sp. (Fig. 18).

St. 75. 4000 m. 45°37′ N, 7°03′ W. 9-3-1909. 4300 m.w., 1^{45} pm., 120 min. 1 ♂ > 101 mm.

The specimen here in question is highly defective; it lacks the flagellum in both pairs of antennæ, and also the tip of the antennal plate, as well as p. 4—p. 5 and the point of the telson and of the outer ramus in the uropoda. The similarity to the two known species is, apart from what is stated above, so striking that there is no occasion to give a description of the entire animal.

Rostrum 5 mm., carapace 27 mm., abdomen (from anterior margin of 1. abdominal segment) 66 mm.

Fig. 18. Ephyrina bifida. Rostrum and eye, and dorsal teeth of 3.—4. abdominal segment.

The rostrum is of the same shape as in KEMP's spec. of *E. Hoskyni* (Kemp 1910, Pl. 7 fig. 1) save that there is a small apical point, and the length is somewhat greater, reaching probably to about the extreme end of the cornea of the eye, but this cannot be stated exactly, as the outermost part of the eye is altogether destroyed. On the inferior margin of the rostrum, there is a furrow on either side, each apparently designed to accomodate one eye; the very thin upright partition between these furrows is furnished with bristles. This formation in the inferior margin of the rostrum is not described in any of the other species. The eyes are very badly damaged, but seem to have been shorter and heavier than in the other species.

Dorsal side of abdominal segments evenly rounded. The 3. segment is drawn out dorsally into a horizontal, plate-like process, bifid for the last third of its length (hence the specific name) and abt. $^1/_3$ the length of the segment in question; the edges are very slightly upturned. No such process is found in the other species; in *E. Hoskyni*, there are indeed no teeth on the caudal segments, while *E. Benedicti* has a single on the 3. caudal segment, at any rate in the two largest known specimens (56—57 mm.) and also in 2 spec. from the "Thor" (see below) of 27 and 33 mm. A single small tooth is found on the back of the 4. caudal segment; nothing of this sort is known at all in the other species. KEMP (1910, p. 71) presumes that both rostrum and teeth on 3. caudal segment are subject to variation, but we know very little of the species here concerned. Only 7 specimens in all of *E. Hoskyni* are known, 8 of *E. Benedicti*. (Besides the spec. mentioned by KEMP 1910, we have, besides the 3 spec. from the "Thor", of *E. Benedicti*, also a further 3 spec. — 1 of *E. Hoskyni*, 2 of *E. Benedicti* — mentioned without further description by COUTIÈRE 1911, p. 157).

It is surely quite out of the question that the present spec. should be identical with *E. Hoskyni*, for the largest specimens of this species described in literature (87—110 mm.) are of the same size as the spec. from the "Thor" and differ, then, in lacking altogether the tooth or process on the 3. caudal segment. On the other hand, it is not quite impossible that the "Thor" spec. might be *E. Benedicti*. Only 3 specimens of this species have been described, (apart from the 3 mentioned below from the "Thor"), and these are at the outside barely half the size of the "Thor" spec. 24 mm. (KEMP), 20—33 mm. ("Thor"), 56 mm. (SMITH) and 57 mm. (BATE). The two smallest of these specimens have no tooth at all on the 3. caudal segment, the others, however, have one, but it is not bifid. Though it is hardly impossible that a single tooth, in the case of smaller specimens, might be found bifid in one of about double the size, it still seems to me best for the time being to maintain the "Thor" spec. as a distinct species.

Telson slightly longer than 6. caudal segment (over 16 mm., as against 14.5 mm.) but lacking the tip; the preserved portion has 6 pairs of lateral spines.

That the specimen is a male is seen from the inner ramus of up. 1, which is of similar shape to that of *Acanthephyra purpurea* (see p. 43) but the stylet is quite short.

2. EPHYRINA BENEDICTI Smith (Fig. 19).

Ephyrina Benedicti Smith 1884, p. 506, no fig.
— — — 1886, p. 674, Pl. 14 fig. 3, Pl. 16 fig. 4.
Tropiocaris planipes Bate 1888, p. 835, Pl. 136 fig. 1.
Ephyrina Benedicti Kemp 1910, p. 71, Pl. 7 fig. 7.

St. 76. > 2600 m. 49°27′ N, 13°33′ W. 11-6-1906. 2800 m.w., 3^{00} pm., 120 min. 3 spec.: abt. 20, 27, 33 mm.

Though the determination of the smallest specimen is, owing to its size, not quite certain, I have, from the presence of the tooth on the 3. caudal segment,

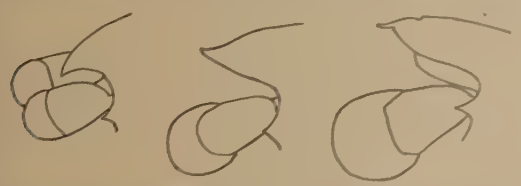

Fig. 19. Ephyrina Benedicti (St. 76, 1906). Rostrum and eye of specimens 20, 27 and 35 mm. in length respectively.

no hesitation in the case of the two larger ones. The smallest specimen hitherto described is probably 24 mm., and lacks the tooth mentioned (Kemp 1910).

The largest spec. from the "Thor" has a distinct tooth on the 3. caudal segment; the rostrum reaches only to the middle of the cornea. The remarkable shape of the rostrum (see fig. 19) is due to the fact that the animal is still soft after moult; on either side of the lower margin there is, as in *E. bifida*, a furrow for partial accomodation of the eyes. The middle specimen has only a very small tooth on 3. caudal segment; the rostrum here reaches to the commencement of the cornea. The smallest specimen has the rostrum markedly bent outward; it hardly reaches as far as the cornea. No tooth on 3. caudal segment, and the 4. segment in p. 3, p. 4 is considerably narrower than in the larger spec.

A curious feature is the change which takes place in the eye as the animal increases in size. In the smallest spec., the cornea is not much larger on the lateral than on the median side, and the diameter is only slightly greater than that of the stalk. This stage seems to answer to that shown by Kemp (1910 fig. 7). On the two larger specimens, the diameter of the cornea is much larger than that of the stalk, and the obliquity of the cornea is also greater, the median side reaching farther down the stalk than the lateral.

In all three specimens, the lateral side of the cornea is (in spirits) light grey in contrast to the whole remaining part, which is a blackish brown.

Distribution. 1. Atlantic. 40°26′40″ N, 67°5′15′ W, 959 fms., 1 spec. (Smith). — 50°28′ N, 11°39′ W, 0—700 fms. w., 1 spec. (Kemp). — 36°—45° N, 11° W, 2 spec. (Coutière 1911, p. 157).

2. Pacific. 26°29′ N, 137°57′ E, 2425 fms., 1 spec. (Bate).

Genus Hymenodora G. O. Sars.

Hymenodora G. O. Sars 1877, p. 340.
— — Norske Nordhavs-Exp. 1885, p. 35.
— (partim) Bate 1888, p. 838.
— de Man 1920, p. 46 (list of species).

1. HYMENODORA GLACIALIS Buchh.

(non H. gracilis Smith).

Pasiphaë glacialis Buchholz 1874, p. 279 Pl. 1 fig. 2.
Hymenodora — G. O. Sars 1877, No. 24.
* — — — 1885, p. 37, 275, Pl. 4.
— — Smith 1886, p. 678, Pl. 15 fig. 3, 10, Pl. 16 fig. 5.
— (partim) Faxon 1895, p. 169.
— — Rathbun 1904, p. 27.
— — H. J. Hansen 1908, p. 79.
— — (partim) Kemp 1910, p. 72 Pl. 8.
non — — Lenz u. Strunck 1914, p. 331.

St. 164. 1900—2150 m. 62°10′ N, 19°36′ W. 12(13)-7-1903. 1 spec. 47 mm.

This specimen is rather small in comparison with the maximal sizes noted in the literature: 68 mm. (H. J. Hansen 1908), 83 mm. (Sars 1885).

A female from the "Ingolf" exped. (locality?) abt. 56 mm., has ova, these measuring abt. 2 × 2.5 mm. The ova, abt. 30 in number, form a compact mass; the separate ova do not appear to be arranged in any regular order (cf. *H. gracilis*, infra). A fig. in Sars (1885, Pl. 4 fig. 2, copied by Kemp 1910, Pl. 8 fig. 1) shows a far greater number of ova. From the measurements given, the animal itself is 58 mm.; the ova of the same dimensions as in the spec. from the "Ingolf".

Colour an intense red, the eyes with a faint golden sheen. (Grieg 1914, p. 19).

Distribution. This species is often combined with *H. gracilis* (infra No. 2) so that we cannot always see from the literature whether one or the other is meant. The distribution, however, would seem to be as follows:

1. Atlantic. The species is bathypelagic and lives at great depths, over 1000 m. below the surface; as a

rule with negative temp. Its principal area seems to be the Norwegian Sea, whence it is recorded by numerous writers, for the rest, it is found N. of a line drawn thus: E. America 37°12$^1/_3$′ N,- 69°36′ W, 2949 fms. (Smith 1886 p. 678 = Smith 1882, p. 502 partim) then S. Iceland 62° N, ("Thor" st. 164, 1903) Færoe Channel abt. 60° N, (Norman 1882, p. 684) and S. W. Ireland (Kemp 1910, p. 73: "the podobranch on the second maxilleped . . . in many cases is totally absent" which is precisely the distinguishing character of this species in contrast to *H. gracilis*). From localities south of this boundary line it has hardly been noted with certainty, being apparently here represented by *H. gracilis*. A more detailed list of localities is given in H. J. Hansen 1908, p. 79, 80 and Rathbun 1904, p. 27; since when some further finds have been added from the waters off S.W. Norway (Wollebæk 1908, p. 73, and Grieg 1914, p. 19) — (Kemp 1907, see *H. gracilis*).

2. Pacific. The following localities: Bering Sea S. of Pribylof Is. 1401 fms. and E. of Prince of Wales Is. Alaska 1569 fms. (Rathbun 1904, p. 27) probably refer to this species.

On the other hand, Faxon 1895, p. 168 notes some specimens from the following 4 localities considerably farther south: Gulf of California 25°29$^1/_3$′ N, 109°48′ W, 1218 fms. and 27°34′ N, 110°53$^2/_3$′ W, 905 fms.; S. W. of Panama 7°21′ N, 79°2′ W, 1832 fms. and W. of Ecuador 1°7′ N, 84° 4′ W, 1740 fms. These localities are noted again by Rathbun 1904, but despite the fact that H. J. Hansen (1908, p. 80) takes it for granted that the determination is correct, it is nevertheless evident from Faxon's text that at any rate 25°29$^1/_2$′ N, gave both *H. glacialis* and *H. gracilis*, and that 7°21′ N, gave only *H. glacialis* (Faxon states nothing as to the spec. from the two other localities) On geographical grounds however, it seems very doubtful whether the true *H. glacialis* would be found in these localities; it would be of importance to have the specimens subjected to revision.

2. HYMENODORA GRACILIS Smith.

Hymenodora gracilis Smith 1886, p. 681, Pl. 12 fig. 6.
glacialis (partim) Faxon 1895, p. 168.
— (partim) Kemp 1910, p. 72.
Lenz & Strunck 1914, p. 331—34, texfig. 5.
gracilis Murray & Hjort 1912 p. 668.

Atlantic.

St. 76. > 2800 m. 49°27′ N, 13°33′ W. 11-6-1906. 2800 m.w., 9^{45} pm., 30 min. 28 spec.: 3 spec. abt 10 mm., 24 spec. 15—30 mm., 1 ♀ with ova 34 mm. — **St. 190.** >4000m. 46°30′ N, 7°00′ W. 11-9-1906. 2700 m.w., 8^{25} am., 150 min. 5 spec. (1 ♀ with ova 35 mm.), 34—38 mm. — **St. 75.** >4000 m. 45°37′ N, 7°03′ W. 9-3-1909. 4300 m.w., 1^{45} pm., 120 min. 3 spec.: 42, 47, 57 mm.

From the shape of the rostrum, the determination is altogether certain, and confusion with *H. glacialis* is out of the question.

The species is generally confused with *H. glacialis*, to which it is closely allied; it may be distinguished, however, *inter alia*, by the very long rostrum, and in having a podobranch on the second maxilliped. It seems to be smaller, max. 57 mm. ("Thor" st. 75, 1909) the largest specimen mentioned in lit. is 55 mm. (Smith 1886) Females with ova are 34—35 mm. ("Thor") as against 58 mm. for *H. glacialis* (Sars 1885, pl. 4 fig. 2).

The colour, too is different, being here orange, with brown eyes (Murray & Hjort 1912, p. 668).

One station (St. 76, 1906) lies S. W. of Ireland, the two others (St. 190, 1906 and St. 75, 1909) are in the Bay of Biscay. Depth to bottom very great, over 2800—over 4000 m. length of wire 2700—4300 m.w. In one haul at any rate it was certainly taken pelagically (St. 190) the length of line being considerably less than the depth to bottom.

Shoals can occur: St. 76 gave 28 in a single haul. A female of 38 mm. from st. 76, 1906 had ova. Compared with the size of the animal itself, the eggs are enormous: 2 × 2.5 mm. Though it can be seen that none have fallen off, the ova are only 7 in number, and placed in a particular manner, filling the space in the curve of the body. On either side, immediately under the belly, there is 1 egg between plp. 1—2 and plp. 2—3, making 4 in all. Behind and outside the interval between the two hindmost eggs there is another single one touching the ventral side. Of the two remaining eggs, one is placed ventrally to the interval between the four above mentioned, in front; the last one is placed in front of, but ventrally to, the interval between the two foremost "paired" eggs. — A female from St. 190 also had ova, but had lost most of them, only 2 remaining.

Distribution. 1. Atlantic. There can be no doubt that this species takes the place of *H. glacialis* S. of the line noted under that species, there being, however, a mixed area at the boundaries, at any rate as regards E. America and S. W. Ireland. In the Norwegian sea it is not found.

The distribution can be stated as follows: E. America 10 spec. from 9 localities 35°45$^1/_2$′—40°26$^2/_3$′ N, 67°05$^1/_4$′—74°31$^1/_2$′ W, 861—2949 fms. (Smith 1886, p. 681 = 1882, p. 502 partim). For S. W. Ireland and the Bay of Biscay see "Thor" supra. — W. of Ireland both species

are found, specimens being noted both with and without podobranch on the 2. mxp. (KEMP 1910, p. 73). — KEMP 1907, p. 213, mentions some macerated fragments from the Bay of Biscay 2000—15000 fms. which he with a (?) refers to *H. glacialis*; owing to the locality, there can hardly be any doubt that they are in reality *H gracilis*.

The only material of any extent recorded in the literature was taken by the "Michael Sars" between Europe and Newfoundland (precise locality not stated; see MURRAY & HJORT 1912, p. 668). It includes in all 221 spec. taken both day and night at a depth of from 750 to over 1500 m.; in the daytime, it was found almost exclusively at 1000—1500 m. (151 out of a total, 160 spec.); at night at the same depths, most numerous however, at 1500 m. below the surface.

Much farther south it has only been taken at 5°27′ N, 21°41′ W, 800 m., 1 spec. 31 mm. (LENZ & STRUNCK 1914).

2. Pacific. FAXON 1895 see under *H. glacialis*.

Genus Notostomus M.-Edw.

Notostomus A. Milne-Edwards 1881, p. 7.
— 1883[1], Pl. 19, 40.
— Smith 1884, p. 377.
— — 1886, p. 676.
— Bate 1888, p. 824.
— Faxon Bull. Mus. Comp. Zool. 24, 1893, p. 207.
— 1895, p. 170.
* — Kemp 1913, p. 65 (key to the species).
Lenz u. Strunck 1914, p. 330.
de Man 1920, p. 46 (list of species).

MURRAY and HJORT 1912, p. 585—86 mention that 13 species are known representing in total 15 specimens; but that the "Michael Sars"-Exped. has 19 specimens representing 5 species, of which 4 new to science; fig. 425 (p. 586) is a new species.

KEMP 1913, p. 66 gives a key to the species; later on a new species is described (*N. atlanticus* Lenz & Strunck see below).

The species are:

1. *N. elegans* Milne-Edwards 1881, p. 8.
- — — 1883.
- Coutière 1911, p. 157.
2. *N. gibbosus* Milne-Edwards 1881, p. 7.
- — — 1883.
3. *N. vexcus* Smith 1886, p. 676 (no fig.).
4. *N. robustus* Smith 1884, p. 377, Pl. 7 fig. 2.
- 1886, p. 676, Pl. 12 fig. 5.
5. *N. patentissimus* Bate 1888, p. 826, Pl. 133 fig. 1-2.
6. - *Murrayi* — p. 829, Pl. 134 fig. 3.
7. *N. longirostris* — p. 833, Pl. 135 fig. 4.
8. *N. perlatus* — p. 831, Pl. 124 fig. 2.
= ?*N. brevirostris* p. 832, Pl. 134 fig. 4 (teste KEMP 1913, p. 65).
N. perlatus Kemp 1913, p. 66, Pl. 7 fig. 10.
9. *N. Japonicus* Bate 1888, p. 830, Pl. 135 fig. 1.
10. *N. Westergreni* Faxon 1893, p. 208.
- — — 1895, p. 171, Pl. F (cold. fig.).
- Stebbing 1910, p. 110.
11. *N. fragilis* Faxon 1893, p. 207.
- 1895, p. 170, Pl. 44 fig. 2.
12. *N. atlanticus* Lenz u. Strunck 1914, see below.
?13. *N. corallinus* Milne-Edwards 1883, Pl. 32. ("Does not seem to be correctly referred to this genus" [KEMP 1913, p. 66]).

[1] I have not had access to this paper.

1. NOTOSTOMUS ATLANTICUS Lenz u. Strunck. (Fig. 20).

Notostomus atlanticus Lenz u. Strunck 1914, p. 330—31 (no fig.).

St. 69. > 3500 m. 36°13′ N, 9°44′ W. 28-2-1909. 3000 m.w., 6^{30} pm., 60 min. 1 ♂ > 107 mm.

Despite the fact that the rostrum is minus its tip, it must evidently have been very long; the portion preserved (from base of the eye-socket) is itself more than half the length of the carapace. Besides the point of the rostrum, most of the flagellum of the antennæ is missing, as also the point of the telson; otherwise, the specimen is extremely well preserved.

Fig. 20. Notostomus atlanticus.

Measurements: rostrum over 20 mm. (apex lost).. Carapace (from the eye to the hind edge) 36 mm. Height of carapace 25 mm. Abdomen + telson over 55 mm. telson over 15 mm. (apex of telson lost).

According to KEMP's key to the species (KEMP 1913, p. 67) the species must be determined as belonging to

the group comprising *N. patentissimus*, *N. Westergreni* and *N. longirostris*; since KEMP's writing of this, however, a new species has been added, namely *N. atlanticus*.

The specimen from the "Thor", however, has a character which would certainly seem to be of great importance, in the lateral carina on either side of the rostrum between the dorsal carina and the two ventral ones, which run out to the post-orbital carina. Such lateral carina is probably found only in *N. Westergreni* and *N. atlanticus*. According to KEMP's "key", the present specimen might belong to *N. Westergreni*, this, however, is out of the question, from the fact that the longitudinal carina between the post-orbital and post-antennal carina in *N. Westergreni* lies abt. midway between the two carinæ, whereas in our specimen here it is decidedly nearer the post-orbital, which agrees with *N. longirostris* (indeed, the position and shape of the carinæ on the carapace are altogether as in *A. longirostris* [BATE 1888, Pl. 135 fig. 4]).

It remains then, only to compare it with *N. atlanticus*, and there can be no doubt that it is identical with this species; LENZ & STRUNCK's description (they give no figure) might, save for the missing parts and the measurements (Thor's specimen is the largest) equally well apply to the "Thor" specimen.

Distribution. 20°41′ N, 31°53′ W, 3000 m.w. 1 spec. 91 mm. (LENZ & STRUNCK).

Fam. Nematocarcinidæ Bate.

Nematocarcinidæ Sp. Bate 1888, p. 481, 927.
— Alcock 1901, p. 85.
— Stebbing, Edinburgh 1914, p. 296 (synonymy).
— de Man 1920, p. 72.

From the "Thor"-area are only known the species mentioned below.

Genus Nematocarcinus M.-Edw.

Nematocarcinus A. Milne-Edwards 1881, p. 14.
— Alcock 1901, p. 86.
— Kemp 1910, p. 76 (lit. and syn.).
— Stebbing, Edinburgh 1914, p. 297 (with lit. and syn.).
— — S. Africa 1914, p. 43.
— Balss, 1914, p. 22.
— de Man 1920, p. 74 (list of species).

NEMATOCARCINUS ENSIFER Smith.

Nematocarcinus ensifer Kemp 1910, p. 75 (lit. and syn.).

NEMATOCARCINUS EXILIS Bate.

Stochasmus exilis Bate 1888, p. 822, Pl. 132, fig. 14.
Nematocarcinus exilis Calman 1896, p. 7.
— — H. J. Hansen 1908, p. 74.
— *ensifer* var. *exilis* Kemp 1910, p. 75, Pl. 9.
— — — — Lenz & Strunck 1914, p. 330.

On the variety *N. ensifer* (S. I. Smith) var. *producta* Bate see de Man 1920, p. 76 (lit.), Pl. 8 fig. 18, 18 a.

On the larva see below.

Atlantic.

St. 93. 1330—1440 m. 49°25′ N, 12°20′ W. 25-6-1905. 2700 m.w. (Shrimp trawl), 7^{45} am., 120 min. 3 ♀. — **St. 74.** 1220 m. 49°23′ N, 12°13′ W. 9-6-1906. 2500 m.w. (Eel drift-seine), 9^{50} pm., 60 min. 16 spec.: 4 ♂, 12 ♀. — **St. 75.** 1520 m. 49°20′ N, 12°39′ W. 10-6-1906. 2800 m.w. (Eel drift-seine), hour?, 90 min. 61 spec.: 30 ♂, 31 ♀. — **St. 178.** 4000 m. 48°04′ N, 12°40′ W. 2-9-1906. 1800 m.w., 9^{05} am., 120 min. 13 spec.: 6 ♂, 7 ♀.

All specimens belong to *N. exilis*, not *N. ensifer*.

The material comprises 93 specimens (40 ♂, 53 ♀) from 4 hauls at 4 stations. All the stations are situate S. W. of Ireland. Depth to bottom 1220—1520 m., disregarding a single station with 4000 m. at which the length of wire out was only 1800; there is no doubt, however, but that the net must have passed bottom at one spot with comparatively slight depth, as the species is undoubtedly not pelagic, but lives on the bottom. A similar instance, albeit less pronounced, is mentioned by KEMP 1910: soundings 800 fms. midwater trawl 750—800 fms. wire.

The ♂ is somewhat smaller than the ♀: 60—70 mm. (one ♂ however, 75 mm.) while the ♀ are 75—80 mm. No females with ova were found. For the larvæ see below.

Distribution of *N. exilis* and *N. ensifer*. In their extreme forms, the two species are well distinguished; there are, however, intermediate forms, whose proper place may be difficult to determine,

In eastern American waters, probably only *N. ensifer* is found, and off S. W. Ireland only *N. exilis* (these are the two localities from which most specimens were taken, and both have yielded extremely large numbers). From this one might suppose that *N. ensifer* was a west-Atlantic form, and the other east-Atlantic. In the Mediterranean, probably both species are found; but if

the records in the literature are correct, *N. exilis* is limited to the western basin, while *N. ensifer* is only found in the eastern; a point which is not without interest, since it would seem that only *N. exilis* is found in the eastern Atlantic, and apparently only *N. ensifer* is found in the Indian Ocean. The material at present available is, however, too slight to serve as basis for reliable results.

For further information, see list of localities below.

A. N. exilis.

1. Mediterranean. 41°14²/₃′ N, 8°18′ E, 2145 m., 1 spec.; 40°24³/₄′ N, 7°43¹/₂′ E, 2836—2809 m., several spec.; 38°38′ N, 9°47′ E, 1600 m., 2 spec.; 39°20¹/₂′ N, 13°10²/₃′ E, 3624 m., 3 spec. (Senna 1903, *N. ensiferus*; but from the measures for the rostrum it is evident that all the specimens are in reality *N. exilis*).

2. Atlantic. S. W. and S. of Iceland, 7 stations, 695—1128 fms., several spec. (H. J. Hansen 1908). — S. W. Ireland, several spec. (Calman 1896, Kemp 1910). — ?Bay of Biscay, *N. ensifer*, Caullery 1896. C. mentions "*N. ensifer*" from 3 stations in the Bay of Biscay (46°28′ N, 7° W, 1710 m.; 44°47′ N, 4°33′ W, 1200 m.; 44°39′ N, 4°30′ W, 650 m.). Our Zool. Mus. possesses one (very defective) spec. from one of these localities, and it may be determined as an intermediate form between the two species. — 30°38′ N, 18°5′ W, depth?, 1 spec. (Bate 1888). — 12°11′ S, 6°16′ W, 2000 m., 1 spec. (Lenz & Strunck 1914).

B. N. ensifer.

1. Mediterranean. 33°4′ N, 21°15²/₃′ E, 1770 m.; 35°26′ N, 23°18′ E, 2525 m.; 35°59′ N, 25°8′ E, 1838 m.; 34°42′ N, 25°14′ E, 1503 m. (Adensamer 1898).

2. Atlantic. E. America 31°41′—41°33¹/₄′ N, 65°51¹/₂′—74°35′ W, 588—2033 fms., several loc., several spec. (Smith 1882, 1884, 1886). —? Biscaya (Caullery 1896, see *N. exilis*). —

3. Indian Oc. Arabian Sea, 5 stations, 824—1200 fms.; Bay of Bengal, 1310 fms. (*N. tenuipes*, Alcock 1901).

4. Pacific. 35°11′ N, 139°28′ E, 345 fms., 6 spec.; 34°7′ N, 138°0′ E, 565 fms., 6 spec.; 2°33′ S, 144°4′ E, 1070 fms., 1 spec. (Bate 1888). — 6 stations at Hawaii, 293—1314 m. (Rathbun 1906, p. 926). — Pacific coasts of America, 19 stations between 0°36′ S and 27°34′ N, 660—1879 fms., several spec.; the typical form is found 0°36′ S to 7°5¹/₂′ N; the specimens from 16°33′ N to 27°34′ N belong to a somewhat obvious race, intermediate forms are found in intermediate localities (Faxon 1895, p. 156).

Larva of ?Nematocarcinus exilis Bate or ?N. ensifer Smith.

Larva allied to *Caricyphus* Sp. Bate, Kemp 1907, p. 213, Pl. 15, fig. 2—8. *Nematocarcinus* sp. juv. (nom. incert.) Kemp 1910, p. 81.

Mediterranean (c. = length of carapace).

St. 115. 2800 m. 38°17′ N, 4°11′ E. 28-6-1910. 300 m.w., 11^{20} pm., 30 min. 1 spec., c. 6 mm. — **St. 115.** ibid. 2000 m.w., 0^{30} am., 60 min. 1 spec., c. 9.5 mm. — **St. 116.** 2860 m. 39°27′ N, 5°26′ E. 30-6-1910. 65 m.w., 2^{20} am., 30 min. 1 spec., c. 4.5 mm. — **St. 116.** ibid. 300 m.w., 1^{40} am., 30 min. 2 spec., c. 5—6.5 mm. — **St. 116.** ibid. 300 m.w., 4^{05} pm., 30 min. 1 spec., c. 6 mm. — **St. 118.** > 2700 m. 41°00′ N. 6°43′ E. 30-6-1910. 65 m.w., 11^{35} pm., 30 min. 2 spec., c. 5.5—7 mm. — **St. 118.** ibid. 300 m.w., 10^{35} pm., 30 min. 2 spec., c. 6—7 mm. — **St. 129.** 3430 m. 40°05′ N, 11°31′ E. 12-7-1910. 300 m.w., 3^{40} am., 30 min. 1 spec., c. 11 mm. — **St. 131.** 915 m. 38°36′ N, 11°00′ E. 13-7-1910. 300 m.w., 10^{35} am., 30 min. 2 spec., c. 8—10 mm. — **St. 131.** ibid. 1000 m.w., 11^{40} am., 60 min. 1 spec., c. 9 mm. — **St. 132.** 1227 m. 38°57′ N, 9°47′ E. 14-7-1910. 300 m.w., 3^{45} am., 30 min. 1 spec., c. 8 mm. — **St. 133.** 600 m. 38°18′ N, 9°59′ E. 14-7-1910. 600 m.w., 9^{30} pm., 30 min. 1 spec., c. 8 mm. — **St. 143.** 1842 m. 35°18′ N, 16°25′ E. 23-7-1910. 300 m.w., 0^{30} am., 30 min. 1 spec., c. 11 mm. — **St. 204.** > 1000 m. 38°52′ N, 7°43′ E. 27-8-1910. 65 m.w., 4^{30} am., 15 min. 1 spec., c. 5 mm. — **St. 207.** 2131 m. 40°34′ N, 3°03′ E. 29-8-1910. 1000 m.w., 6^{00} am., 45 min. 2 spec. 3.5—8 mm. — **St. 276.** ("Pangan") > 3000 m. 36°30′ N, 19°20′ E. 4-4-1911. 132 m.w., 11^{55} pm., 35 min. 40 spec., c. 3.5—8.5 mm.

Atlantic.

St. 167. 1160—1300 m. 51°25′ N, 11°50′ W. 26-8-1906. 200 m.w., 10^{30} am., 120 min. 3 spec. c. 10 mm. — **St. 173.** 390 m. 51°31′ N, 11°37′ W. 30-8-1906. 200 mw., 60 min., 8^{15} am., 1 spec., c. 13 mm.

The only certain fact at present known about the development of *Nematocarcinus* is that Kemp 1910 (p. 79 Pl. 9 fig. 9—10) gives a brief description and figure of a Zoea picked out from the ovum. Size is not stated, but since he gives (p. 78) the size of a mature egg as 1.1 × 0.67 mm., the newly hatched larva can hardly be much over 2 mm. long. Shortly before (1907) he had described and figured an older larva from the Bay of Biscay, 15—25 mm., which he referred, in 1910, with some uncertainty, to *Nematocarcinus, inter alia* on account of the branchial formula. Though certainly not of great importance, it might perhaps be further pointed out that the larva taken from the egg has long rostrum and rather pronounced "elbow" on the 3. caudal segment, as in the case as the larger larva, which after all to some extent confirms the presumed relationship between the two.

The larvæ taken by the "Thor" agree entirely with KEMP's description and fig. (KEMP 1910) save for such differences as are due to dissimilarity in size. KEMP's larvæ have a total length of 15—33 mm.; those from the "Thor" on the other hand 10—40 (owing to the marked elbow in the 3. caudal segment, the length can hardly be measured with absolute accuracy, and I have therefore measured the carapace, the length of which is noted in the above list of localities; the carapace, however, seems to be very nearly $^1/_3$ total length.)

Without dissection, the only age differences I have been able to observe were as follows: In the smallest spec., (carap. = 3.5 mm.) p. 5 is entirely lacking; caudal fan already present. When c. is 6 mm., p. 5 is still quite diminutive; pleopoda not yet indicated. When c. is 6.5 mm., p. 5 is somewhat larger, pleopoda indicated, but still quite small, not bifid. Spec. with carapace from abt. 8—9 mm. answer to KEMP's figure. When c. is 11 mm., the pleopoda are considerably larger, but as a rule without natatory setæ; in one specimen, the rostrum is equal in length to the carapace minus rostrum. When c. is 13 mm., natatory setæ have appeared at the point of the pleopoda.

All specimens have exopods on p. 1—4. Eyes (in spirits) pale grey, colourless.

The "Thor" has 63 specimens, of which 59 in the Mediterranean, only 4 in the Atlantic. The 2 Atlantic stations are both S.W. Ireland, all Mediterranean stations in the western basin except 2, which lie between Sicily and Greece. Depth at one station only 390 m., otherwise much greater, as a rule over 1000 m.

Vertical occurrence. At night, it was taken almost exclusively with 65—300 m.w. never nearer the surface, and only 3 times deeper still. In the daytime it keeps practically speaking only to a depth answering to 200—300 m.w. All the larvæ were from end July to end August, save for a shoal of 40 spec. taken in the Mediterranean 4. April.

M. w.	No. of hauls	
	Night	Day
65	3	—
132—200	1	2
300	6	2
600	1	—
1000—1200	2	1

For KEMP's larvæ, the following data are given: Bay of Biscay 50—100 fms. w. (date?) 4 spec. 15—25 mm. (KEMP 1907) S.W. Ireland 80—750 fms. w. 5. Aug—12. Sept. 14 spec. 25—35 mm.

There seems to be no direct relation between vertical occurrence and size, or date and size. As a rule, each haul contained only 1—2 spec., only one haul giving 40 spec.

Palinura (Eryonidea + Scyllaridea).

Eryonidea de Haan.

Eryonidea Stebbing 1910, p. 377 (lit.).

This group comprises only a single family, the *Eryonidæ*, with 4 genera (*Eryoneicus*, *Polycheles*, *Stereomastis*, *Willemoësia*) all of which were found within the "Thor" area. DE MAN 1916, p. 4—6, gives a list of all genera and species.

Depth to bottom great, over 500—1000 m. often even far more than this, up to 4000 m. (see DE MAN 1916, p. 4—6).

The three genera are bottom forms with firm, brittle skin, the fourth (*Eryoneicus*) on the other hand, is bathypelagic with at any rate generally soft skin.

Their deep-sea life is apparent in their external appearance. Eyes colourless and can hardly function; the first established species of the family, *Polycheles typhlops* HELLER 1862, takes its specific name from this fact.

The colour can only be stated in some few cases. *Polycheles sculptus pacificus* is pale rose purple and bluish white, the setæ yellow (see FAXON 1895, p. 123, Pl. C., fig. 1 [col. fig.]) and *Eryoneicus coecus pacificus* is purplish red, the branchial regions livid (FAXON ibid., p. 115, Pl. B., fig. 2 [col. fig.]). ALCOCK 1901 gives the colour for some species of *Polycheles*, *Willemoësia* and *Eryoneicus*; it is pink or milky white, in *Eryoneicus* also with or without a touch of brown or white. Excellent coloured figures of several species are given by BOUVIER 1917, Pls. 2—4, 7.

Nothing is known as to propagation. SUND (1915) has revived the old hypothesis according to which *Eryoneicus* is taken to be the larval or juvenile form of *Polycheles* (+ *Stereomastis*) which was at once strongly contradicted by BOUVIER (1915). SELBIE (1914, p. 40, Pl. 4, figs. 6—9) describes a mysis stage of *Eryoneicus* sp.

From the "Thor" area we have altogether 11 (10) known species, all of which were also taken by the "Thor" with the exception of the three mentioned below.

Willemoësia leptodactyla Will.-Suhm (BATE 1888, p. 163, Pl. 18—20) is said to have been taken (1 spec.) off the west coast of Sicily (GIGLIOLI in "Nature" vol. 24, 1881, p. 358; Ann. Sic. Nat., ser. 6, vol. 13, p. 5); possibly this record is based on error, since DE MAN l. c. gives its distribution as N. and S. Atlantic 1900 fms.

and West coast of South America 1375—2275 fms., without mentioning any finding of the species in the Mediterranean.

Eryoneicus Puritani Lo Bianco (1903, p. 187—88, Pl. 9, fig. 24; Bouvier 1905 [3], p. 6) has been taken at the following localities: Capri 500 and 1200 m.w., and closing net with 1000 and 1900 m.w., total 5 spec. 5—10 mm., all taken in the middle of the day; 10 am. to 3^{30} pm. (Lo Bianco 1903); Azores surface 1 spec. and Bay of Biscay 1500 m.w. depth to bottom 4780 m. 1 spec. (Bouvier l. c.).

? *Stereomastis nanus* Smith was perhaps taken in the area; but this cannot be stated with certainty, as it was formerly lumped together with *S. Grimaldii* (see Selbie 1914, p. 21—23).

Just outside the limits of the area, another species has been taken, *Eryoneicus Scharffii* (Selbie 1914, p. 35, Pl. 5, figs. 9—12; S.W. Ireland); also *E. Alberti* (Bouvier 1905 [2], p. 645; Bouvier 1905 [4], p. 4; Bouvier, Bull. Inst. Océanogr. Monaco, No. 93, 1907, fig. 36, p. 46; 35°04′ N, 32°11′ W, 0—2000 m., 1 spec.).

Fam. Eryonidæ Dana.

Eryonidæ Stebbing 1910, p. 377 (lit.).
— Selbie 1914, p. 8.
— de Man 1916, p. 1 (with list of all genera and species).
— Pesta 1918, p. 161.
— Bouvier 1917, p. 26.

Genus Eryoneicus Sp. Bate.

Eryonicus Selbie 1914, p. 26 (lit and key to the species).
— Sund, Eryonicus-Polycheles; "Nature", June 3, 1915.
Eryoneicus Bouvier, Observations nouvelles sur le genre Eryoneicus; Bull. Inst. Océanogr. Monaco, No. 309, 1915.
— de Man 1916, p. 6 (list of species, distrib., vertical occurence).
— Bouvier 1917, p. 54 (key to species).

Selbie (l. c.) has given a key to the species known; some alterations, however, must be made in consequence of information since published.

E. hibernicus Selbie is synonymous with *E. spinoculatus* Bouv. (Bouvier 1915, p. 2). Two species have been added since Selbie's list appeared; viz. *E. atlanticus* (Lenz & Strunck 1914, p. 292, Pl. 13, 14) and *E. Richardii* (Bouvier 1915, pp. 6—8).

1. ERYONEICUS SPINOCULATUS Bouvier.

Eryoneicus spinoculatus Bouvier 1905 (3), p. 7 (no fig.).
Eryonicus hibernicus Selbie 1914, p. 29, 33, Pl. 5, figs. 1—2 (*teste* Bouvier 1915, p. 2).
Eryoneicus spinoculatus Bouvier 1917, p. 74, Pl. 3, figs. 5—8 (col. figs.), Pl. 4, figs. 1—12.

St. 75. 4000 m. 45°57′ N, 7°53′ W. 9-3-1909. 4500 m.w., 1^{45} pm., 120 min. 1 spec. 34 mm.

This specimen, though rather soft, is yet considerably firmer-skinned than any of the other species here concerned. Dorsal spines on the abdomen are: 1, (1 +) 1, 2, 2, 2 (+ 1), 1, (2 +) 1 (the figures in brackets denoting very small spines).

Disregarding the peculiarity in the matter of spines on the dorsal side of abdomen, the spec. agrees very well with Bouvier's and Selbie's descriptions.

Distribution. S.W. Ireland, 0—1150 fms., 1 spec., 34 mm. (Selbie). — Terceira (Azores), 2870 m., 1 ♂ 35 mm. (Bouvier).

2. ERYONEICUS RICHARDI Bouvier.

Eryoneicus Richardi Bouvier 1915, p. 6 (no fig.).
— — — 1917, p. 68, Pl. 6, figs. 3—10, Pl. 7, figs. 1—4.

St. 64. 2140 m. 49°17′ N, 14°03′ W. 5-6-1906. 300 m.w., 120 min., 10^{35} pm. 1 spec. abt. 45 mm.

At this station, the "Thor" took a specimen which must be referred to this species, though in certain respects I have been unable to make it agree with Bouvier's description. The specimen is very soft and very hirsute, and was further entirely enveloped in remains of medusæ which clung to the hairs, making it very difficult to clean it even approximately without damage.

Ant. 1 and 2 are not short, as stated by Bouvier, but as long as in the other species. The formula for teeth on the dorsal carina of the carapace agrees; for the reasons stated above, however, I was unable to determine how far this also applies to the other carinæ. P. 3—5 are cheliform, not sub-cheliform; this, however, is possibly only due to difference in size of the specimens. Spines on dorsal side of tail: 1, 3, 3, 3, 3, 2, 1.

Thus, in spite of the fact that various details could not be determined with certainty (especially spines on the carinæ of the carapace, save for the dorsal) I have

nevertheless no hesitation in referring the present specimen to this species, especial from the entire agreement with regard to teeth on the dorsal carina of the carapace and lack of teeth on outer margin of 1. joint in the peduncle of ant. 1. All existing species with the exception of *E. Richardi* have 1 or 2 teeth here, possibly, however, with exception of *E. Alberti*, *E. Puritani* and *E. spinulosus*, for which species nothing is stated as to this character; these last three species, however, are out of the question here, from the mere fact of their having an entirely different formula for teeth on the dorsal carina of the carapace.

Distribution. Cap Finisterre in Spain (Monaco St. 3312), 0—3500 m., 1 spec., carapace 15 mm. (Bouvier l. c.).

3. ERYONEICUS FAXONI Bouvier.

Eryoneicus Faxoni Bouvier 1905 (1), p. 482.
— — — 1905 (3), p. 5.
Eryonicus — Selbie 1914, p. 29, Pl. 4, figs. 1—5.
Eryoneicus — Bouvier 1917, p. 78, Pl. 4, figs. 14—15 (col. fig.), Pl. 5, figs. 13—16.

Mediterranean.

St. 129. 3420 m. 40°05′ N, 11°31′ E. 12-7-1910. 3500 m.w., 3^{05} pm., 120 min. 1 spec. 13 mm.

Atlantic.

St. 178. 4000 m. 48°04′ N, 12°40′ W. 2-9-1906. 1800 m.w., 120 min., 1 spec. 22 mm.

The arrangement of the median abdominal spines in both specimens is as in the specimen from Ireland, SR 806 (Selbie, p. 32).

Distribution. 1. Mediterranean. SW of the Balcares, 0—2375 m., 1 spec., size? (Bouvier 1905 [2]).

2. Atlantic. SW Ireland, 0—893 fms., 5 spec., 13.5—35 mm. (Selbie). — Off Cap Cantin (West coast of Morocco), 2200 m., 1 spec., 30 mm. (Bouvier 1905 [1, 3]).

4. ERYONEICUS KEMPI Selbie.

Eryonicus Kempi Selbie 1914, p. 37, Pl. 5, figs. 3—8.

Mediterranean.

St. 15. 1000 m. 40°14′ N, 19°06′ E. 22-12-1908. 1400 m.w., 5^{20} am., 60 min. 1 spec. 17 mm. — **St. 115.** 2800 m. 38°17′ N, 4°11′ E. 29-6-1910. 2000 m.w., 0^{30} am., 60 min. 2 spec. 18 mm.

The spines of the median carina of the carapace are arranged as in Selbie's specimens.

The median spines of the abdominal segments are arranged thus: (stat. 15) 1, 2, 2, 2, 2, 1, 1; (stat. 115) 1, 2, (1 +) 2, 3, (1 +) 2, (2 +), 1, (1 +) 1, and 1, 2, (1 +) 2, 2, 3, 2, (1 +) 1, 1. (The figures in ( ) indicate very small spines).

Distribution. 1. The species is new to the Mediterranean.

2. Atlantic. SW Ireland, 523—735 fms., 2 spec., 22—25 mm. (Selbie).

Genus Stereomastis Sp. Bate.

Stereomastis de Man 1916, p. 4 (list of species), p. 7 (lit.).
Polycheles (partim) Bouvier 1917, p. 35 (key to Atlantic species).

1. STEREOMASTIS SCULPTA S. I. Smith.

Polycheles sculptus Senna 1903, p. 338 (lit. and syn.).
— — H. J. Hansen 1908, p. 41.
— — Selbie 1914, p. 11, 18, Pl. 2, figs. 1—9.
Stereomastis sculpta de Man 1916, p. 8 (lit. and syn.).
Polycheles sculptus Bouvier 1917, p. 51 (lit. and syn.), Pl. 3, fig. 1 (col. fig.).

Atlantic.

St. 93. 1275—1180 m. 49°25′ N, 12°20′ W. 25-6-1905. 2 spec. 67—70 mm. — **St. 74.** 1220 m. 49°23′ N, 12°13′ W. 9-6-1906. Eel drift-seine, 2500 m.w. 1 spec. 44 mm. — **St. 178.** 4000 m. 48°04′ N, 12°40′ W. 2-9-1906. 1800 m.w. 2 spec. 46—55 mm.

The three smallest specimens from the "Thor" are soft, the two largest are hard. All specimens have the formula noted by Selbie for teeth on the median carina of the carapace.

Distribution. 1. Mediterranean. 3 localities SW of Corsica, 2145—2835 m. (Senna 1903).

2. Atlantic. N. Atlantic 62°—abt. 45° N (see H. J. Hansen 1908 and Selbie 1914). — On the "Thor" see above. — S of Madeira 32°32½′ N, 17°02′ W, 1968 m. (Bouvier 1905 [4], p. 4). — See also Bouvier 1917, p. 51.

3. Indian Ocean. See Selbie 1914, p. 20. — 7°28.2′ S, 115°24.6′ E, 1018 m., 1 ♂ 5°40.7′ S, 120°45,5′ E, 1158 m., 1 ♂ (de Man 1916).

2. STEREOMASTIS GRIMALDII Bouvier.

Polycheles Grimaldii Bouvier 1905 (3), p. 4 (no fig.).
— *nanus* var. *Grimaldii* Selbie 1914, p. 21, Pl. 1, figs. 14—15.
Stereomastis Grimaldii de Man 1916, p. 4.
Polycheles — Bouvier 1917, p. 52, Pl. 3, figs. 2—4 (col. fig.).

Atlantic.

St. 78. 4000 m. 48°04′ N, 12°40′ W. 2-9-1906. 1800 m.w. 3 spec.: 44, 53, 63 mm.; the largest spec. is a ♀ with ova.

The smallest spec. has 2 spines at the inner angle of the orbital sinus; on the left, the one is shifted markedly over towards the rostrum. A female with ova in our museum ("Ingolf" st. 40, 74 mm.) has 2 spines on the left, only one on the right.

The largest specimen has the following formula for teeth down the back of the carapace: 2, 1, 1, 1, 1, 2, 1; 2, 2, 2. The other specimens have the usual formula (see Selbie). H. J. Hansen 1908 mentions spec. with 3, 4 and 5 unpaired spines just behind the rostrum (N. B., all the specimens of "*Polycheles nanus*" mentioned by H. J. Hansen 1908 from the "Ingolf" really belong to the species *S. Grimaldii*). Females with ova are: 56—74 mm. ("Thor" st. 78; "Ingolf" st. 10, 18, 40, 41, 67, 68, 83).

Distribution. Davis Straits, W, SW and S of Iceland, 695—1435 fms., (all the specimens from the "Ingolf"-Exp., *P. nanus* H. J. Hansen 1908). — SW Ireland, 982 fms. (Selbie). — Numerous localities see Bouvier 1917, p. 52.

The distribution is possibly far wider that this, but the point cannot be decided from extant literature, as the species was formerly lumped together with *S. nana*. For the distribution of *S. nana* (+ *S. Grimaldii*) see Selbie, p. 23; de Man, on the other hand (1916) has altogether overlooked H. J. Hansen's work 1908 on the "Ingolf"-Exped.

Genus Polycheles Heller.

Polycheles (partim) Selbie 1914, p. 9 (lit.).
— de Man 1916, p. 5 (list of species), p. 21 (lit.).
— (partim) Bouvier 1917, p. 34 (key to Atlantic species).

1. POLYCHELES TYPHLOPS Heller.

Polycheles typhlops Selbie 1914, p. 12 (lit. and syn.), Pl. 1, figs. 1—13.
Polycheles typhlops de Man 1916, p. 24 (lit. and syn).
— — Pesta 1918, p. 162 (lit. and syn.), textfig.
— — Bouvier 1917, p. 36 (lit. and syn.), Pl. 2, figs. 1—6 (col. fig.).

Atlantic.

St. 80. 960 m. 51°34′ N, 11°50′ W. 16-6-1906. Eel drift-seine, 1900 m.w. 1 spec. 70 mm.

Distribution. 1. Mediterranean. Adria (see Pesta l. c.). — From Sardinia to south coast of Asia Minor (Lo Bianco 1903, p. 250; Selbie, p. 16). — See also Bouvier 1917, p. 37.

2. Atlantic. It was not taken by the "Ingolf" and thus does not appears to go very far north. The outer limits for distribution are $59^1/_2°$ N (see below), West Indies (see Selbie) and Cape Verde Islands (Bouvier 1917). Bouvier 1917, pp. 37 and 43 gives numerous localities. — 59°37′ N, 8°49′ W, 1326 m. (*P. intermedius*, Balss, Zool. Anzeiger, vol. 44, 1914, p. 599, teste de Man 1916).

3. Indian Ocean. From the Arabian Sea to the Malabar coast, several loc. 7°15′ S, 115°15.6′ E, 289 m., 1 ♀; 7°35.4′ S, 117°28.6′ E, 521 m., 1 spec. (de Man 1916).

2. POLYCHELES GRANULATUS Faxon.

Polycheles granulatus Selbie 1914, p. 23, Pl. 3 (lit. and syn.).
— de Man 1916, p. 5.
— — Bouvier 1917, p. 45 (lit. and syn.), Pl. 2, figs. 7—14 (col. fig.).
non Polycheles Beaumontii(?) Stebbing 1908, p. 25, — *P. Beaumontii*(?) Stebbing 1910, p. 377, = *P. Demani* n. sp. Stebbing 1918, p. 28, Pl. 92.

Atlantic.

St. 74. 1220 m. 49°23′ N, 12°13′ W. 9-6-1906. Eel drift-seine, 2500 m.w. 1 spec. 44 mm.

P. dubius Bouv. and *P. eryoniformis* Bouv., which were taken together at a st. S. of Madeira, 1968 m., are noted by Selbie and Bouvier 1917 as synonymous with *P. granulatus*, but established by de Man 1916, p. 5, as independent species.

Total length of the spec. from the "Thor" is 44 mm.; carapace is 16 mm. broad, 20 mm. long.

The specimen agrees excellently with Selbie's description but some observations must be made. On

the margin of the carapace we find on the right side the following no. of teeth: 8 (incl. the foremost large tooth) 3, 15; on the left side, 7, 3, 15. On the outer margin of the orbital sinus (apart from the large corner tooth), right, 2 teeth, left only 1. Median carina on back of carapace has, from the rostrum, first 5 single teeth, then some granulations; behind the cervical groove there are in the middle 2, 1,2, 2,1 teeth, while in front and behind there are only some granulations.

Distribution (Atlantic, Indian Ocean, Pacific) see SELBIE, p. 25—26, and BOUVIER 1917, pp. 46—47 and 50.

Scyllaridea Stebbing. (Fam. Scyllaridæ + Palinuridæ).

Scyllaridea Pesta 1918, p. 164 (lit. and syn.).
Loricata Bouvier 1917, p. 81.

In addition to the three species which are distributed throughout the whole of the "Thor" area, (*Scyllarus arctus, Scyllarides latus, Palinurus vulgaris*) 4 others are also stated as found within the limits of that area, viz. *Palinurus Thomsoni* Selbie (1914, p. 43, Pl. 6, figs. 1—2; SW Ireland 212—229 fms.). *Palinurus vulgaris* Latr. var. *mauritanica* Gruvel 1911 (DE MAN 1916, p. 32: Coast of Mauritania from Cape Barbas to a little N of St. Louis, Senegambia), *Panulirus regius* de Brito Capello 1864 (DE MAN 1916, p. 34: West Africa from Cape Barbas to the South of Angola; observed in 1907 off Marseille by DARBOUX and STEPHAN), and *Thenus orientalis* (T.-Lund) Fabr. (see below p. 76).

In the material, only one species, *Scyllarus arctus*, is represented by adult specimens. We have, however, the Phyllosomæ of 4 species, of which two can be determined with certainty, viz. *Scyllarus arctus* and *Palinurus vulgaris*. The entire developmental series of *Palinurus vulgaris* was previously known; in the case of the commonest Mediterranean form, however, *Scyllarus arctus*, only the first Phyllosoma stages and the natant stage were known. The "Thor" has found all the intermediate stages, so that this species also is now known throughout its entire development from the egg to the adult.

The two other larvæ taken by the "Thor" are referred to *Scyllarides latus* and *Thenus orientalis*; in the remaining species, nothing is known as to development beyond a mention by BOUVIER of the natant stage of *Panulirus regius*, (BOUVIER: Le stade Natant ou "Puérulus" des Palinuridés; Transact. Second Entomol. Congress 1912, pp. 85—87).

Fam. Scyllaridæ Gray.

Scyllaridæ de Man 1916, p. 64 (list of all genera and species).
Pesta 1918, p. 168 (lit. and syn.).
Bouvier 1917, p. 98.

Genus Scyllarus Fabr.

Scyllarus de Man 1916, p. 64 (list of all species).
Pesta 1918, p. 172 (lit.).
— Bouvier 1917, p. 105.

1. SCYLLARUS ARCTUS L.

(= **ARCTUS URSUS** Hbst.). (Chart 7, figs. 21—24).

A. **Full grown stage.**

Scyllarus arctus Pesta 1918, p. 172 (lit. and syn.), text-fig. 56.
— — A. Milne-Edwards, in Cuvier, Règne Animal, Crust., p. 119, Pl. 45, fig. 1.
— — Bouvier 1917, p. 106.

Mediterranean.

St. 149. 75—80 m. 30°30′ N, 19°02′ E. 26-7-1910. Dredge. 1 spec. 32 mm.

B. **Development** *(Phyllosoma* and *Natant-stage).*

Chrysoma mediterraneum Risso, Hist. Nat. mérid. de l'Europe[1], tome 5, p. 88, Pl. 3, fig. 9 (*teste* GUÉRIN 1833).
Phyllosoma mediterranea Guérin 1833, No. 11, Pl. 13, fig. 2.
— — Claus 1863, p. 425, Pl. 25, figs. 2—4 (stage I).
Claus 1863, p. 431, Pl. 27, figs. 11—12 (st. VIII).
Scyllarus arctus Dohrn 1870, p. 251—60, Pl. 16, figs. 8—10.
Phyllosoma mediterranea Richters 1873, p. 638 (separate p. 16), Pl. 33, fig. 1.
? — *Raynaudii* Richters 1873, p. 638 (separate p. 16), Pl. 32, fig. 2.
? — *Duperreyi* Richters 1873, ibid., Pl. 33, fig. 3.
(non — — Guérin 1833, No. 9, Pl. 12.
non — *Raynaudii* Guérin 1833, No. 10, Pl. 13, fig. 1).
Scyllarus arctus Hornell, J.: The Phyllosoma a Glass-Crab larva of Scyllarus; Journ. Marine Zool., vol. 1, No. 3, 1894, p. 69—74.[1]
— — Williamson 1915, p. 436, fig. 195.

[1] I have not had access to this paper.

Nisto lævis + *N. asper* Sarato, Etudes sur les Crustacés de Nice, genre Arctus, Dana, sousgenre Nisto Nob.; Le Moniteur des étrangers de Nice, 1er mars 1885[1] (*teste* Bouvier l. c. 1913).

— — — Bouvier 1913, p. 1644, 1647—48.

— — — Bouvier 1917, p. 108, Pl. 10, figs. 1—2, Pl. 11, figs. 1—2.

B. 1: *Phyllosoma.*

Mediterranean.

St. 10. > 2100 m. 37°21′ N, 16°45′ E. 15-12-1908. 65 m.w. 6^{15} am., 15 min. Stage VII, 15 mm. — **St. 10.** ibid. 300 m.w., 8^{00} am., 30 min. Stage VI, 8 mm. — **St. 11.** 3750 m. 36°50′ N, 18°16′ E. 16-12-1908. 25 m.w., 4^{00} am., 60 min. Stage VI, 12 mm.; st. VII, 19 mm. — **St. 11.** ibid. 65 m.w., 5^{25} am., 60 min. St. VII, 19 mm. — **St. 13.** > 1200 m. 39°43′ N, 17°30′ E. 19-12-1908. 15 m.w., 10^{15} pm., 60 min. St. VI, 8 mm.; st. VII, 16 mm.; st. VIII (2 spec.), 23 mm. — **St. 13.** ibid. 300 m.w., 5^{25} pm., 60 min. St. VI, 8 mm.; st. VII, 16 mm. — **St. 14.** 1125 m. 41°24′ N, 17°45′ E. 19-12-1908. 65 m.w., 5^{00} am., 60 min. Stage VII, 15 mm. — **St. 21.** > 500 m. 37°51′ N, 15°21′ E. 5-1-1909. 10 m.w., 11^{50} pm., 30 min. St. VI, 13 mm. — **St. 22.** > 750 m. 38°57′ N, 15°18′ E. 7-1-1909. 25 m.w., 30 min., 8^{00} pm. St. VII, 17 mm. — **St. 26.** 560 m. 40°40′ N, 13°59′ E. 19-1-1909. 65 m.w., 0^{45} am., 60 min. St. VI, 11 mm. — **St. 26.** ibid. 300 m.w., 6^{40} am., 180 min. St. VI, 12 mm.; st. VIII, 21 mm. — **St. 28.** 600 m. 43°53′ N, 13°43′ E. 19-1-1909. 25 m.w., 7^{30} pm., 60 min. St. VII, 18 mm. — **St. 28.** ibid. 400 m.w., 6^{40} pm., 30 min. St. VIII, 23 mm. — **St. 30.** > 1800 m. 41°15′ N, 11°55′ E. 21-1-1909. 65 m.w., 5^{20} pm., 60 min. St. VI, 12 mm.; st. VII, 20 mm. — **St. 31.** 1420 m. 41°44′ N, 10°52′ E. 22-1-1909. 65 m.w., 4^{30} am., 30 min. St. VI, 15 mm. — **St. 33.** 150 m. 43°04′ N, 9°35′ E. 22-1-1909. 65 m.w., 6^{30} pm., 30 min. St. VI, 15 mm. — **St. 38.** > 75 m. 40°45′ N, 9°50′ E. 31-1-1909. 25 m.w., 7^{10} pm., 30 min. St. V, 8 mm. — **St. 39.** 1750 m. 39°41′ N, 10°02′ E. 1-2-1909. 25 m.w., 5^{00} am., 60 min. St. VI (2 spec.), 9-10 mm.; st. VII, 19 mm. — **St. 39.** ibid. 65 m.w., 6^{10} am., 60 min. St. VI, 11 mm. — **St. 58.** 85 m. 36°36′ N 04°24′ W. 20-2-1909. 100 m.w., 2^{00} pm., 30 min. St. VIII, 22 mm. — **St. 59.** 1250 m. 36°02′ N, 4°24′ W. 21-2-1909. 100 m.w., 1^{00} am., 30 min. St. VIII, 22 mm.; st. VII, 15 mm. — **St. 115.** 2800 m. 38°17′ N, 4°11′ E. 29-6-1909. 25 m.w., 1^{40} am., 15 min. St. V (4 spec.), 4.5—5 mm.; st. VI (3 spec.), 7—8 mm.; st. VII, 9 mm.; st. VIII, 19 mm. — **St. 115.** ibid. 65 m.w., 1^{20} am., 15 min. St. V, 6 mm.; st. VIII, 21 mm. **St. 115.** ibid. 2000 m.w., 0^{20} am., 60 min. St. IV, 4 mm.; st. V (3 spec.), 5—6 mm. — **St. 116.** 2860 m. 39°27′ N, 5°26′ E. 30-6-1910. 25 m.w., 3^{00} am., 15 min. St. V, 5 mm.; st. VI, 11 mm. — **St. 116.** ibid. 300 m.w., 1^{40} am., 30 min. St. VI, 8 mm. — **St. 118.** > 2700 m. 41°00′ N, 6°43′ E. 1-7-1910. 25 m.w., 0^{20} am., 15 min. St. VII (2 spec.), 13 mm. — **St. 118.** ibid. 65 m.w., 11^{35} pm., 30 min. St. VI, 8 mm. — **St. 123.** > 600 m. 44°14′ N, 8°55′ E. 3-7-1910. 10 m.w., 2^{30} am., 15 min. St. V, 6 mm.; St. III, 3 mm. — **St. 123.** ibid. 25 m.w., 1^{50} am., 15 min. St. IV (2 spec.), 3—4 mm.; st. V (2 spec.), 5—6 mm. — **St. 125.** 1082 m. 43°54′ N, 9°13′ E. 9-7-1910. 25 m.w., 10^{30} pm., 30 min. St. III, 2.5 mm.; st. VI (2 spec.), 9—10 mm. — **St. 125.** ibid. 300 m.w., 9^{45} pm., 30 min. St. VI, 9 mm. — **St. 126.** 588 m. 42°43′ N, 9°50′ E. 10-7-1910. 25 m.w., 30 min., 10^{10} pm. St. III, 3 mm.; st. V, 6 mm. — **St. 129.** 3420 m. 40°05′ N, 11°31′ E. 12-7-1910. 300 m.w., 3^{40} am. 30 min. St. IV, 4.5 mm. — **St. 130.** > 3000 m. 39°35′ N, 11°20′ E. 13-7-1910. 25 m.w.,.0^{50} am., 30 min. St. VII, 12 mm. — **St. 132.** 1227 m. 38°57′ N, 9°47′ E. 14-7-1910. 25 m.w., 3^{05} am., 30 min. St. V, 8 mm.; st. VI (2 spec.), 10 mm.; st. VII, 12 mm. — **St. 133.** 602 m. 38°18′ N, 9°59′ E. 14-7-1910. 25 m.w., 11^{00} pm., 30 min. St. V (3 spec.), 5 mm.; st. VI, 9 mm.; st. VII (3 spec.), 10—11 mm. — **St. 134.** 350 m. 37°37′ N, 10°17′ E. 15-7-1910. 25 m.w., 4^{50} am., 30 min. St. IV, 3.5 mm. — **St. 134.** ibid. 300 m.w., 5^{40} am., 30 min. St. II, 1.5 mm. — **St. 136.** 80 m. 37°01′ N, 10°31′ E. 19-7-1910. 25 m.w., 3^{10} am., 30 min. St. IV, 4 mm. — **St. 137.** 175—195 m. 37°17′ N, 10°56′ E. 19-7-1910. 25 m.w., 8^{15} am., 30 min. St. IV, 3 mm. — **St. 138.** 788 m. 37°37′ N, 11°25′ E. 19-7-1910. 25 m.w., 9^{50} pm., 30 min. St. III, 2.5 mm.; st. IV (2 spec.), 3—4 mm. — **St. 139.** 580 m. 37°57′ N, 11°54′ E. 20-7-1910. 800 m.w., 3^{40} am., 60 min. St. III, 3 mm. — **St. 141.** 530 m. 36°42′ N, 13°34′ E. 20-7-1910. 25 m.w., 10^{35} pm., 15 min. St. IV, 4 mm.; st. VI, 9 mm. — **St. 142.** 98 m. 35°44′ N, 15°07′ E. 22-7-1910. 150 m.w., 3^{40} am., 30 min. St. IV, 4 mm. — **St. 143.** 1842 m. 35°18′ N, 16°25′ E. 23-7-1910. 25 m.w., 1^{20} am., 30 min. St. V (2 spec.), 5—6 mm.; st. VII, 18 mm. — **St. 144.** 3340 m. 34°31′ N, 18°40′ E. 24-7-1910. 25 m.w., 2^{00} am., 30 min. St. V (3 spec.), 5—7 mm.; st. VI (2 spec.), 10—12 mm.; st. VII (2 spec.) 16—18 mm.; st. VIII (2 spec.), 21 mm. — **St. 144.** ibid. 2000 m.w., 3^{45} am., 60 min. St. VI, 9 mm. — **St. 145.** 1925 m. 32°38′ N, 19°02′ E. 25-7-1910. 25 m.w., 3^{30} am., 30 min. St. III, 3 mm.; st. VI (2 spec.), 10—11 mm.; st. VII (3 spec.), 13—18 mm. — **St. 152.** > 2200 m. 33°11′ N, 21°44′ E. 27-7-1910. 25 m.w., 10^{50} pm., 15 min. St. VII, 18 mm. — **St. 154.** 365 m. 32°10′ N, 24°46′ E. 29-7-1910. 300 m.w., 4^{30} am., 30 min. St. VI, 9 mm. — **St. 156.** > 3000 m. 32°24′ N, 26°51′ E. 30-7-1910. 25 m.w., 2^{15} am., 30 min. St. IV, 3 mm.; st. V (5 spec.), 5—9 mm.; st. VI (2 spec.) 10 mm.; st. VII (2 spec.) 14—16 mm. — **St. 156.** ibid. 300 m.w., 3^{50} am., 30 min. St. VI, 9 mm. — **St. 156.** ibid. 600 m.w., 3^{00} am., 30 min. St. VIII, 21 mm. — **St. 158.** 2800 m. 34°23′ N, 27°57′ E. 31-7-1910. 300 m.w., 7^{30} am., 30 min. St. VII (2 spec.), 17—18 mm.; st. VIII, 22 mm. — **St. 160.** > 1000 m. 35°59′ N, 28°14′ E. 1-8-1910. 25 m.w., 2^{00} am., 30 min. St. IV (2 spec.), 3 mm.; st. V (3 spec.), 4—6 mm.; st. VI, 13 mm. — **St. 161.** > 1000 m. 36°12′ N, 27°16′ E. 2-8-1910. 25 m.w., 3^{00} am., 30 min. St. V, (5 spec.), 4—7 mm.; st. VI (3 spec.), 16—17 mm.; st. VII, 19 mm. — **St. 163.** 1180 m. 37°52′ N, 26°22′ E. 3-8-1910. 25 m.w., 1^{35} am., 15 min. St. IV, 3 mm. — **St. 174.** 120 m. 40°54′ N, 28°53′ E. 11-8-1910. 65 m.w., 11^{50} am., 30 min. St. III—V (9 spec.), 3—5 mm. — **St. 175.** 1103 m. 40°48′ N, 27°59′ E. 11-8-1910. 100 m.w., 10^{45} pm., 15 min. St. IV, 4 mm.; st. V, 6 mm.; st. VII (2 spec.), 12—14 mm.; st. VIII (2 spec.), 18—20 mm. — **St. 175.** ibid. 1200 m.w., 0^{25} am., 30 min. St. IV, 4 mm. — **St. 175.** ibid. 400 m.w., 10^{20} pm., 30 min. St. IV, 4 mm.; st. VI, 8 mm. — **St. 176.** > 500 m. 40°45′ N, 27°43′ E. 12-8-1910. 65 m.w., 4^{00} am., 30 min. St. II, 2 mm.; st. III (6 spec.), 3 mm.;

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st. IV (5 spec.), 4—4.5 mm.; st. V (2 spec.), 6 mm.; st. VI, 7 mm.; st. VII (3 spec.), 12—14 mm.; st. VIII, 18 mm. — **St. 178.** 68 m. 40°16′ N, 26°32′ E. 12-8-1910. 65 m.w., 0^{20} pm., 15 min. St. I, 1.5 mm. — **St. 179.** 85 m. 40°02′ N, 25°55′ E. 13-8-1910. 65 m.w., 2^{15} am., 30 min. St. II, III, IV (18 spec.), 2—4 mm. — **St. 181.** 255 m. 38°49′ N, 25°09′ E. 13-8-1910. 65 m.w., 2^{55} pm., 15 min. St. III, 3 mm.; st. IV, 4 mm.; st. V (2 spec.), 5—6 mm.; st. VI, 6 mm. — **St. 182.** 480 m. 38°13′ N, 24°48′ E. 13-8-1910. 10 m.w., 11^{00} pm., 15 min. St. VI (2 spec.), 8—9 mm.; st. VII, 12 mm.; st. VIII, 20 mm. — **St. 182.** ibid. 65 m.w., 10^{30} am., 15 min. St. V, 5 mm.; st. VI, 9 mm. — **St. 182.** ibid. 600 m.w., 11^{40} pm., 30 min. St. IV, 4 mm.; st. V, 5 mm.; st. VI (4 spec.), 8—10 mm. — **St. 183.** 233 m. 37°52′ N, 23°09′ E. 16-8-1910. 65 m.w., 5^{10} pm., 15 min. St. IV, 4 mm.; st. V, 5 mm.; st. VI, 7 mm.; st. VII, 12 mm. — **St. 183.** ibid .300 m.w., 4^{45} pm., 15 min. St. VIII (4 spec.), 20—21 mm. — **St. 186.** > 3000 m. 37°57′ N, 19°51′ E. 17-8-1910. 65 m.w., 12^{00} pm., 15 min. St. VII (2 spec.), 11—15 mm. — **St. 192.** 652 m. 38°07′ N, 15°35′ E. 20-8-1910. 25 m.w., 8^{40} pm., 15 min. St. V, 5 mm. — **St. 193.** > 100 m. 38°15′ N, 15°39′ E. 21-8-1910. 10 m.w., 0^{50} am., 30 min. St. VIII, 20 mm. — **St. 194.** 1140 m. 38°33′ N, 15°29′ E. 21-8-1910. 25 m.w., 5^{00} am., 15 min. St. VII (2 spec.), 12—17 mm. — **St. 195.** 3160 m. 39°02′ N, 14°55′ E. 21-8-1910. 65 m.w., 6^{50} pm., 15 min. St. V, 5 mm. — **St. 197.** > 1000 m. 40°34′ N, 13°36′ E. 24-8-1910. 25 m.w., 7^{45} pm., 15 min. St. III, 2 mm.; st. V (2 spec.), 5—6 mm.; st. VII (2 spec.), 11—14 mm. — **St. 199.** 2700 m. 39°32′ N, 10°49′ E. 25-8-1910. 1000 m.w., 10^{10} pm., 30 min. St. V, 4 mm. — **St. 202.** 760 m. 38°59′ N, 9°25′ E. 26-8-1910. 300 m.w., 5^{05} pm., 15 min. St. VIII, 19 mm. — **St. 204.** > 1000 m. 38°52′ N, 7°43′ E. 27-8-1910. 25 m.w., 4^{00} am., 15 min. St. VI (2 spec.), 6—8 mm. — **St. 204.** ibid. 65 m.w., 4^{30} am., 15 min. St. IV, 4 mm.; st. V (2 spec.), 5—6 mm. — **St. 204.** ibid. 300 m.w., 5^{00} am., 30 min. St. IV, 4 mm. — **St. 204.** ibid. 1000 m.w., 5^{55} am., 30 min. St. VI, 7 mm. — **St. 205.** 2860 m. 39°16′ N, 5°52′ E. 27-8-1910. 25 m.w., 7^{35} pm., 30 min. St. VI (3 spec.), 7—10 mm.; st. VII (6 spec.), 13—18 mm. — **St. 206.** 2782 m. 39°32′ N, 5°15′ E. 28-8-1910. 25 m.w., 0^{30} am., 15 min. St. V (3 spec.), 5—8 mm.; st. VI (2 spec.), 9—11 mm.; st. VII, 12 mm. — **St. 206.** ibid. 300 m.w., 1^{05} am., 15 min. St. V, 6 mm. — **St. 206.** ibid. 1000 m.w., 1^{40} am., 45 min. St. V, 7 mm.; st. VI (3 spec.), 8—12 mm. — **St. 207.** 64 m. 39°58′ N, 3°41′ E. 28-8-1910. 25 m.w., 8^{40} pm., 15 min. St. I, 1.5 mm.; st. IV, 2.5 mm. — **St. 207.** ibid. 65 m.w., 9^{20} pm., 15 min. St. 1V, 3 mm. — **St. 208.** > 1600 m. 40°13′ N, 3°20′ E. 29-8-1910. 25 m.w., 1^{40} am., 15 min. St. V, 6 mm.; st. VI (4 spec.), 9 mm.; st. VII, 15 mm. — **St. 209.** > 2000 m. 40°34′ N, 3°03′ E. 29-8-1910. 25 m.w., 4^{55} am., 15 min. St. V (3 spec.), 6—7 mm.; st. VI, 9 mm. — **St. 209.** ibid. Vertical haul, 75—35 m., 4^{10} pm. St. VI, 8 mm. — **St. 209.** ibid. 100 m.w., 3^{45} pm., 20 min. St. V (2 spec.), 5—6 mm.; st. VI (5 spec.), 7—12 mm. — **St. 209.** ibid. 150 m.w., 4^{25} pm., 20 min. St. V, 5 mm.; st. VI (3 spec.), 8—9 mm.; st. VII (3 spec.), 10 mm. — **St. 209.** ibid. 2000 m.w., 7^{25} am., 45 min. St. VI (4 spec.), 8—10 mm. — **St. 210.** 775 m. 41°10′ N, 2°23′ E. 30-8-1910. 25 m.w., 2^{45} am., 30 min. St. IV—V (40 spec.), 4—7 mm.; st. VI—VII (abt. 60 spec.), 8—13 mm.; st. VIII, 23 mm. — **St. 210.** ibid. 600 m.w., 3^{35} am., 30 min. St. VI (2 spec.), 9—10 mm. — **St. 220.** 375 m. 36°23′ N, 0°43′ E. 4-9-1910. 25 m.w., 2^{15} am., 30 min. St. VIII, 26 mm. — **St. 223.** > 2000 m. 36°13′ N, 1°28′ W. 5-9-1910. 25 m.w., 4^{35} am., 15 min. St. VI, 10 mm.; st. VII, 13 mm. — **St. 223.** ibid. 300 m.w., 4^{55} am., 30 min. St. V, 5 mm.; st. VII (2 spec.), 15—17 mm. — **St. 276** ("Pangan"). > 3000 m. 36°30′ N, 19°20′ E. 4-4-1911. 132 m.w., 11^{55} pm., 35 min. St. IV (3 spec.), 3.5—4 mm.; st. V (5 spec.), 5—7 mm.; st. VI—VII (4 spec.), 11—16 mm. — **St. 277** ("Pangan"). > 3000 m. 33°20′ N, 27°30′ E. 6-4-1911. 11^{35} pm., 35 min., 132 m.w. St. VI, 9 mm.; st. VII (3 spec.), 13—14 mm. — **St. 296** ("Pangan"). > 2000 m. 32°10′ N, 29°50′ E. 25-6-1911. 28 m.w. 2^{30} am., 30 min. St. III, 3 mm.; st. VIII, 19 mm. — **St. 297** ("Pangan"). > 2000 m. 33°10′ N, 25°35′ E. 25-6-1911. 28 m.w. 12^{00} pm., 30 min. St. V—VII (21 spec.), 5—14 mm.; st. VIII, 23 mm. — **St. 298** ("Pangan"). > 2000 m. 34°20′ N, 21°10′ E. 26-6-1911. 38 m.w., 12^{00} pm., 30 min. St. V, 8 mm.; st. VI, 10 mm. — **St. 339** ("Pangan"). > 2000 m. 40°30′ N, 3°10′ E. 20-8-1911. 28 m.w., 3^{00} am., 30 min. St. V, 5 mm.; st. VI, 10 mm. — **St. 340** ("Pangan"). > 2000 m. 35°50′ N, 21°30′ E. 26-8-1911. 28 m.w., 9^{00} pm. St. V—VII (24 spec.), 6—15 mm.; st. VIII (6 spec.), 19—24 mm. — **St. 341** ("Pangan). > 2000 m. 34°0′ N, 26°20′ E. 27-8-1911. 28 m.w., 11^{30} pm., 30 min. St. VI, 12 mm.; st. VIII (2 spec.), 22—24 mm. — **St. 729** ("Nordboen"). 200 m. 41°00′ N, 17°44′ E. 14-4-1913. St. VI, 12 mm.

Atlantic.

St. 190. > 4000 m. 46°30′ N, 7°00′ W. 11-9-1906. 65 m.w., 0^{45} am., 120 min. St. VIII (2 spec.), 19—21 mm. — **St. 8.** > 600 m. 36°33′ N, 7°36′ W. 4-12-1908. 65 m.w., 8^{20} pm., 30 min. St. V, 7 mm.; st. VI (2 spec.), 9—11 mm. — **St. 63.** 490 m. 35°50′ N, 6°03′ W. 22-2-1909. 600 m.w., 1^{15} am., 60 min. St. VII, 13 mm. — **St. 65.** > 1300 m. 35°53′ N, 7°26′ W. 24-2-1909. 25 m.w., 5^{50} am., 30 min. St. VI, 11 mm.; st. IX, 26 mm. — **St. 65.** ibid. 65 m.w., 6^{30} am., 60 min. St. VII—VIII (4 spec.), 16—18 mm.; st. IX (3 spec.), 17—27 mm. — **St. 65.** ibid. 300 m.w., 7^{45} am., 120 min. St. VI (2 spec.), 16—17 mm.; st. VIII, 22 mm. — **St. 65.** ibid. 600 m.w., 10^{00} am., 120 min. St. IX, 20 mm. — **St. 66.** > 735 m. 36°16′ N, 6°52′ W. 25-2-1909. 25 m.w., 0^{05} am., 30 min. St. VII, 18 mm. — **St. 66.** ibid. 65 m.w., 1^{45} am., 60 min. St. VII, 16 mm. — **St. 68.** 550 m. 36°39′ N, 7°21′ W. 27-2-1909. 65 m.w., 7^{00} pm., 30 min. St. VI (2 spec.), 10—11 mm. — **St. 68.** ibid. 800 m.w., 5^{55} pm., 45 min. St. IX, 21 mm. — **St. 69.** > 3500 m. 36°13′ N, 9°48′ W. 1-3-1909. 25 m.w., 0^{30} am., 30 min. St. IX, 22 mm. — **St. 69.** ibid. 65 m.w., 10^{45} pm., 30 min. St. IX, 22 mm. — **St. 69.** ibid. 300 m.w., 3^{05} pm., 30 min. St. VII, 11 mm. — **St. 69.** ibid. 300 m.w., 11^{40} pm., 30 min. St. VIII—IX (3 spec.), 21—28 mm. — **St. 71.** 1150 m. 39°35′ N, 9°45′ W. 5-3-1909. 25 m.w., 0^{05} am., 30 min. St. IX, 20 mm. — **St. 74.** 2000 m. 44°21′ N, 7°55′ W. 8-3-1909. 300 m.w., 10^{50} pm., 60 min. St. IX, 21 mm. — **St. 89.** 1310 m. 36°28′ N, 8°22′ W. 18-6-1910. 65 m.w., 3^{00} am., 15 min. St. VI (2 spec.), 7 mm. — **St. 89.** ibid. 1000 m.w., 4^{10} am., 30 min. St. V, 5 mm. — **St. 91.** 1225 m. 35°53′ N, 7°26′ W. 18-6-1910. 1600 m.w., 5^{25} pm., 60 min. St. VII, 11 mm. — **St. 95.** 275 m. 35°57′ N, 6°00′ W. 23-6-1910. 65 m.w., 5^{50} am., 30 min. St. IX? (VIII?), 15 mm. — **St. 232.** 3760 m. 36°28′ N, 9°26′ W. 9-9-1910. 25 m.w., 8^{50} pm., 30 min. St. V, 6 mm.; st. VII (2 spec.), 10—11 mm. — **St. 232.** ibid. 300 m.w., 10^{35} pm., 30 min. St. VI, 7 mm. — **St. 234.** 920 m. 38°10′ N, 9°20′ W. 10-9-1910. 25 m.w., 9^{45} pm., 30 min. St. VIII,

19 mm. — **St. 242.** 4941 m. 46°19′ N, 6°48′ W. 16-9-1910. 65 m.w., 10^{55} pm., 30 min. St. V, 5 mm.; st. VII (2 spec.), 14-16 mm.; st. VIII, 21 mm. — **St. 242.** ibid. 4350 m.w., 7^{00} pm., 60 min. St. VII, 15 mm. — **St. 264** ("Ingolf"). > 3200 m. 38°14′ N, 24°35′ W. 19-3-1911. 25 m.w., 7^{30} pm., 30 min. St. VI, 7 mm.; st. VII, 11 mm. — **St. 266** ("Ingolf"). > 4300 m. 40°47′ N, 21°10′ W. 20-3-1911. 47 m.w., 7^{30} pm., 30 min. St. IX, 23 mm. — **St. 375** ("Florida"). > 3500 m. 40°11′ N, 12°11′ W. 21-7-1911. Surf., 4^{15} am., 30 min. St. VI—VII (20 spec.), 8—15 mm. — **St. 375.** ibid. 30 m.w., 4^{10} am., 30 min. St. V, 7 mm.; st. VI, 11 mm.; st. VII (2 spec.), 15 mm. — **St. 386** ("Pangan"). 1000 m. 36°30′ N, 7°30′ W. 15-11-1911. 122 m.w., 5^{30} am., 30 min. St. III, 2.5 mm.

B. 2: *The Natant-stage.*

Mediterranean.

St. 11. > 3700 m. 36°57′ N, 18°16′ E. 16-12-1908. 300 m.w. 9^{30} am. 1 spec. 21 mm.

Atlantic.

St. 190. > 4000 m. 46°30′ N, 7°00′ W. 11-9-1906, 65 m.w., 0^{45} am., 120 min. 1 spec. 16 mm. — **St. 71.** 1150 m. 39°35′ N, 9°45′ W. 4-3-1909. 300 m.w., 8^{40} pm., 120 min. 1 spec. 27 mm. — **St. 234.** 920 m. 38°10′ N, 9°20′ W. 10-9-1910. 25 m.w., 9^{45} pm., 30 min. 1 spec. 14 mm.

The material comprises only 1 adult specimen, but 553 Phyllosomæ and 4 spec. in the natant stage. Nearly all were taken in the Mediterranean.

In the following, I take first the morphological characters in the different Phyllosoma stages (and the natant), then passing to the biology. The larval development was previously in part unknown, only the youngest Phyllosoma and natant stages being known; the "Thor", however, has joined up these two extremes by a regular sequence of intermediate stages.

Literature and determination of the larvæ.

Williamson (1915) gives a survey of what is known as to the development; several of the writers he mentions, however, do not really refer the larvæ they investigated to a definite species, but only to the genus *Scyllarus*.

All that the writers themselves have referred with certainty to the present species is that Dohrn (1870) hatched out a larva from the egg and shown that this larva was undoubtedly identical with that shown by Claus (1863, fig. 2—4).

According to Williamson's account 1915 from Hornell 1893 (Hornell's work I have not been able to consult) it would seem that H. also hatched out the young larva he describes, but he does not appear to have seen more that the first stage of it. The natant stage, however, is described by Sarato (whose work I have not seen) under the name of *Nisto lævis* + *N. asper*, shown by Bouvier 1913; Sarato's and Bouvier's works, however, were unknown to Williamson at the time.

As far as I can see, no other larvæ or developmental stages have been referred by the writers in question to this species. That a number of the larvæ described and figured in the literature can with considerable degree of probability be referred to this species is another matter; for these, see under the separate stages.

The "Thor" material.

The "Thor" has collected all the larval stages, right from the newly hatched Phyllosoma to the natant stage. The correctness of the determination is apparent partly from the fact that the first stage agrees exactly with the larvæ hatched out and described by Claus 1863 and Hornell 1894, and partly from the fact that one can, in some few specimens of the oldest Phyllosoma, clearly discern through the skin the antennal plate with 5 large teeth of similar shape to the largest ones in the natant stage.

There are 9 Phyllosoma stages in all; in some of them, however, the difference between the previous and succeeding ones is only slight. The stage of development of p. 4—5 and the abdomen, with corresponding pleopoda and urop. seems to give the best means of distinguishing the stages, and I have therefore used these characters, and describe them first accordingly, afterwards going through the development of eyes, antennæ and oral parts, these, however, do not seem to afford quite such good age characters, as they do not altogether keep pace in point of development with the pereiopoda and the abdomen; the antennæ, for instance, may often be alike in two specimens which must, from the abdominal development, be classed as different stages.

Phyllosoma stages (figs. 21—23).

A. Pereiopoda and abdomen (fig. 21).

1. stage. 1.5 mm. Newly hatched larva (Claus 1863, p. 425, Pl. 25, figs. 2—4; Hornell 1894 in Williamson 1915, p. 437, fig. 195). The identity of the larva shown by Claus was pointed out by Dohrn (1870, p. 256). — I have not been able to consult Hornell l. c. and only know his work from the brief report of it given in Williamson l. c. with a rather poor copy of Hornell's figure. There can be no doubt that the larva here in question is identical with that described and figured by Hornell, which was hatched out in England; unfortunately, W.'s copy of Hornell's figure does not reproduce the tip of the tail, and this is particularly

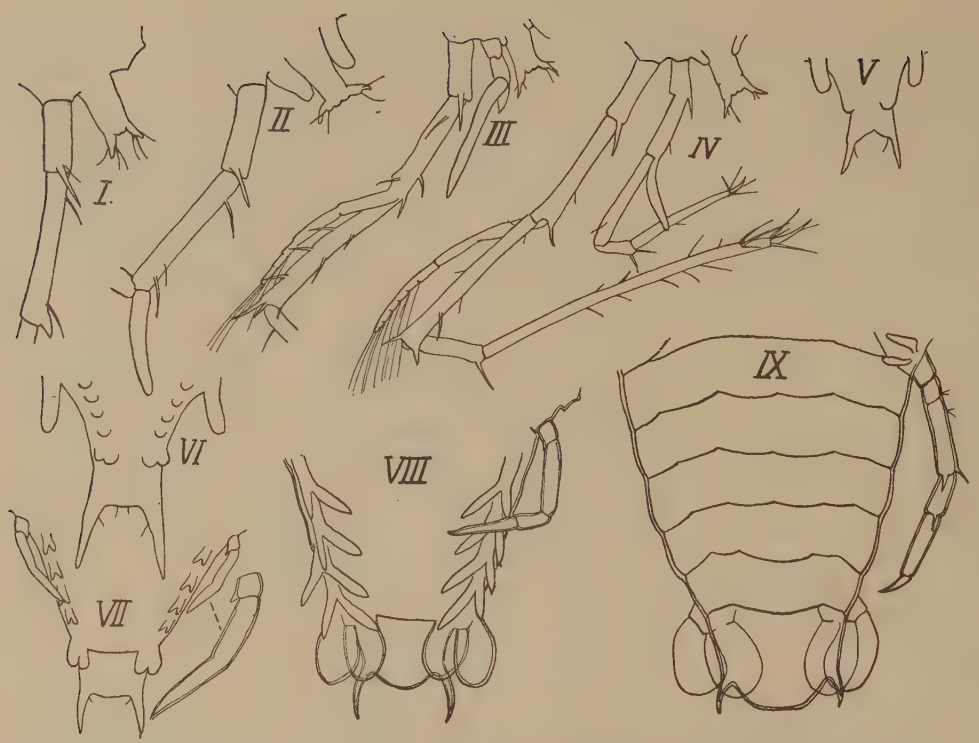

Fig. 21. Scyllarus arctus. Abdomen etc. of the Phyllosoma-stages. I—IX = 1. to 9th stage.

characteristic (see my fig.) being drawn out into a not very long point on either side, armed with three bristles. For the rest, this stage is characterised by lacking exopodite on p. 3, the second joint of which is furnished at its distal end with a short, rather thick process.

2. stage. 1.5—2 mm. The process at distal end of 2. joint in p. 3 now nearly as long as the joint and is now articulated, showing clearly that it is really the exopodite. P. 4 indicated, but much shorter than abdomen.

3. stage. 2.5—3 mm. The exopodite in p. 3 is now fully developed and has natatory setæ. P. 4 abt. 3—4 times as long as the abdomen, with a slight exopodite. P. 5 indicated as a small process.

4. stage. 3—5 mm. P. 4 has grown considerably, as also its exopodite. P. 5 grown somewhat, but not much.

5. stage. 4—9 mm. (*Phyllosoma mediterranea*, Richters 1873, p. 638 (separately p. 16), Pl. 33, fig. 1; loc.: Sicily). P. 4 fully developed. P. 5 half the length of abdomen minus the large terminal spines. Urop. distinctly indicated as a pair of warty protuberances (in a few cases they could be already distinguished faintly in the foregoing stage).

6. stage. 7—15 (17) mm. P. 5 grown somewhat longer. Plp. 2—5 indicated as small protuberances. Urop. bifid at the point.

7. stage. (9) 12—20 mm. P. 5 has not increased appreciably in length, but is thinner and divided into two joints, the proximal very short, terminating in a small spine, the apical very long, with an indication of articulation at the middle; further articulation discernible through the skin. Plp. 2—5 increased in length and bifid. Urop. somewhat longer than in previous stage. The telson now separated off by a sinus from the remaining part of the abdomen, which is not otherwise articulated; posterior margin between the spines slightly convex.

8. stage. (?15) 18—23 mm. (Claus 1863, p. 431, Pl. 27, figs. 11—12; *Ph. mediterranea* Guérin 1833. No. 11, Pl. 13, fig. 2; ?*Ph. Reynaudii* Richters 1873, p. 638 [separately, p. 16], Pl. 33, fig. 2 [loc.: Sicily], but this can despite its great resemblance, hardly be identical with *Ph. Reynaudii* (Guérin 1833, No. 10, Pl. 13, fig. 1) which is from a region [Rangoon and Pondicherry] where *Scyllarus arctus* has never been found). — P. 5 has grown a little in length and now consists of 4 joints (in some specimens, however, there are 5, the dactyl forming a joint by itself). Plp. much longer and deeply cleft; the same applies to the urop. but the rami not yet articulated to peduncle. Posterior margin of telson highly convex. Apart from the telson, there is no articulation between the different segments of the abdomen; in some places, however, a trace of articulation can be discerned through the skin, especially distinct midway down the back (but not out to the sides).

9. stage. (17) 20—28 mm. (? *Ph. Duperreyi*, Richters 1873, p. 638 [separately, p. 16], Pl. 33, fig. 3 [loc.?], but cannot be identical with *Ph. Duperreyi* Guérin 1833, No. 9, pl. 12, for this is from Port Jackson, and the telson is different). — Articulation of the tail now visible through the skin at all segments, but the telson is the only one really free. The two spines on the telson

have become somewhat smaller than in the previous stage. Dactyl in p. 5 now a distinct joint. On the plp. the appendix interna of the inner ramus is distinctly visible through the skin: the next stage is the natant stage.

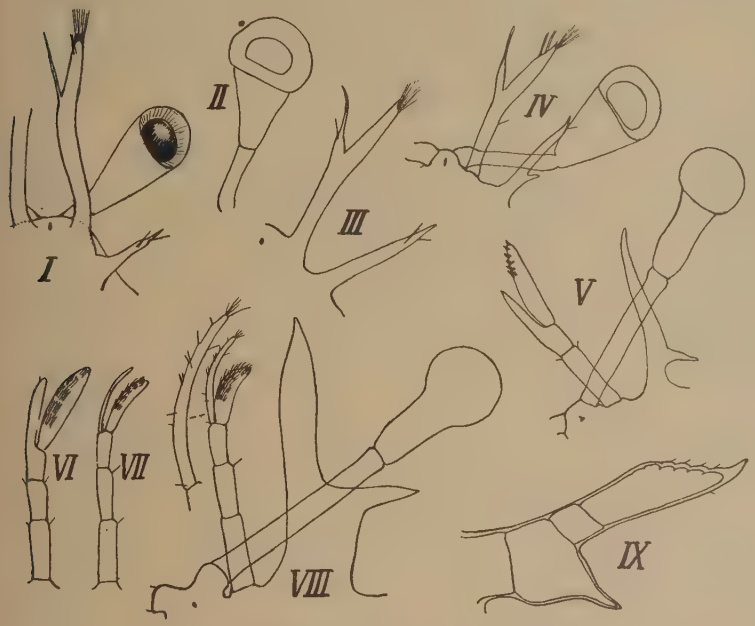

Fig. 22. Scyllarus arctus. Antennæ and eye of the Phyllosoma-stages. I—IX = 1. to 9th stage.

B. Eyes and Antennæ (Fig. 22).

1. stage. The eyes thick-stalked and apparently immobile. Ant. 1 longer than the eyes, and hardly articulated to the carapace; at commencement of the extreme third of its length there is a long thin process, and abt. 4 bristles (broken in all spec.) at the tip. Ant. 2 only abt. $^1/_3$ the length of ant. 1, not articulated.

2. stage. The eye-stalk consists of a proximal cylindrical part connected by articulation with the distal, conical part.

3. stage. In Ant. 1, the long bristle has become greatly thickened at its base, and it is clearly seen to be inarticulate. Besides the setæ at the point of the ant. 1 there is a small tooth. Ant. 2 somewhat longer being now $^2/_3$ the length of ant. 1.

4. stage. The eye a good deal longer, and the stalk clearly articulated to the carapace. Articulation between carapace and Ant. 1. Ant. 2 has developed a process on the outer side of the end of the proximal third.

5. stage. Eye still longer, the cornea itself of much greater diameter than the stalk. Ant. 1, now consists distinctly of 3 joints, and has developed many more sensory setæ. Ant. 2 further prolonged.

6. stage. Peduncle in ant. 1 now divided into 3 joints, (5 stage has 2) occasionally, ant. 1 has at this stage same shape as st. 7.

7. stage. The process at point of 3 joint in peduncle (i. e. inner flagellum) now distinctly articulated at its base, and as long as the joint which becomes the outer flagellum. Also, both the eyes and the two pairs of ant. are further prolonged.

8. stage. Ant. 1, has now the inner flagellum still more prolonged, and armed with bristles. Ant. 2 very large and heavy, but not yet articulated.

9. stage. One can now see through the skin that ant. 2 is divided into 3 joints, the distal one has on the median side 5 teeth as in the natant stage.

C. Oral Parts (Fig. 23).

1. stage. Upper lip convex, the lower cleft. Md. very much the same shape as described and figured by Richters (1873, p. 631 [separately p. 9], Pl. 32, fig. 1) in *Phyllosoma longicorne*, and the same applies to mx. 1 (Richters l.c., Pl. 32, fig. 2). Mx. 2 and mxp. 2—3 (mxp. 1 not yet indicated) can be seen in Claus 1863, Pl. 25, fig. 2—3, but mx. 2 consists in reality of 2 joints, there being a very small apical joint (see my fig. 23).

6. stage. Even here the oral parts are essentially the same, save that mx. 2 has lost its apical joint, and mxp. 1 is now in formation as a small protuberance between mx. 2 and mxp. 2. In some cases, mxp. 1 can be seen in formation already at the 5. stage (Richters 1873, Pl. 33, fig. 1).

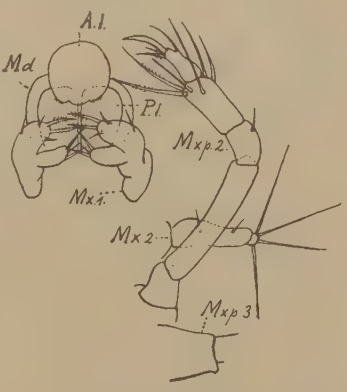

Fig. 23. Scyllarus arctus. Oral parts of a Phyllosoma, 1. stage.

7. stage. Mx. 2 now very broad; mxp. 1 a cylindrical process, as long as mx. 2.

8. stage. (Richters 1873, Pl. 22, fig. 2′). Mx. 2 beginning to assume same shape as in the adult, with indication of a large exopodite. The same can, in some specimens, also be found in mxp. 1 being then approximately as shown in Richters 1873, Pl. 22, fig. 3′. Mxp. 2 has exop. in formation.

9. stage differs nowise from the more developed spec. of 8. stage as regards the oral parts.

The Natant stage. (10. stage). (Fig. 24).

(*Nisto lævis* + *N. asper* Sarato l.c., *teste* Bouvier l.c. 1913)[1].

Bouvier l.c. 1913 gives a characterisation of this stage (but without fig.) showing that it has already long since been described by Sarato, who did not, however, realise its true nature, but regarded *Nisto* as a sub-genus of *Scyllarus*. Sarato's work has also been apparently ignored by all writers, being published in a little-known journal which is not even of zoological character.

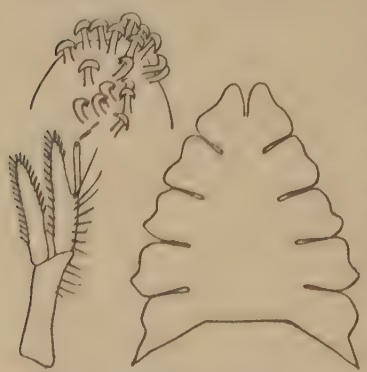

Fig. 24. Scyllarus arctus, Natant stage. Plp. 5 and sternum.

I have here shown two of the characters where by this stage is most readily distinguished from the adult, viz. the sternum with the long points at the base of p. 5 and a pleopod (Fig. of these parts in the adult see Milne-Edwards l.c. whose fig. of plp. 3 [Pl. 45, fig. 1 C] however, only applies to the male; in the female, the inner ramus of the three hindmost pairs of plp. is as long as the outer ramus [though quite thin] to serve as a holder for the ova).

The two largest specimens from the "Thor" (20—21 mm.) are hard-shelled like the adults; the two smallest (14—16 mm.) still soft. The smallest specimen then, is not more than half the size of the largest 9. Phyllosoma stage (28 mm.).

The natant stage attains the same size as the young, fully developed *Scyllarus*, 18—22 mm., (Sarato, teste Bouvier). The fishermen of Nice are said to know them so well that they even have a special name for them: "machottes blanches". This, however, must doubtless be taken with some reserve, as we can hardly suppose the fishermen would be able to distinguish them from the adults, which they so greatly resemble. It is more remarkable that Sarato (teste Bouvier) has seen or taken "plus de 150 échantillons" for other writers do not know this stage, and not even Bouvier (1913), who goes through Sarato's work, seems to have seen a single specimen himself. They are said to be taken at night with a dredge at 30—40 fms. depth.

All the 4 spec. from the "Thor" were taken pelagically at 920—over 4000 m. depth, by day with 300 m.w., at night with 25, 65 and 300 m.w.

[1] Bouvier's paper 1917 with elaborate descriptions (pp. 108 seq.) and several figures (Pl. 10, figs. 1-2; Pl. 11, figs. 1-2) I have not seen till the present paper was ready to the press; see the note p. 3.

A. Mediterranean. (Phyllosoma).

From here we have 479 Phyllosomæ, of which the "Thor" has taken 403, and 1 natant stage.

"Thor" 1908—10	No. of stations	Hauls	Specimens
Dec. 1908	4	7	12
Jan. 1909	8	10	12
Feb. —	3	4	7
June 1910	2	5	18
July —	22	29	75
Aug. —	26	42	273
Sept. —	2	3	6
total...	67	100	403

Depth of the sea and occurrence (Chart 7).

The depth to bottom for the Phyllosoma is 64—>3000 m. and over; experiments with a view to ascertaining whether the species prefers any particular depth within these limits gave no definite result.

Depths in m.	No. of stations
0— 250 m..	12
> 250— 500 - ..	5
> 500—1000 - ..	14
> 1000—2000 - ..	18
> 2000—3000 - ..	11
> 3000 - ..	7
total...	67

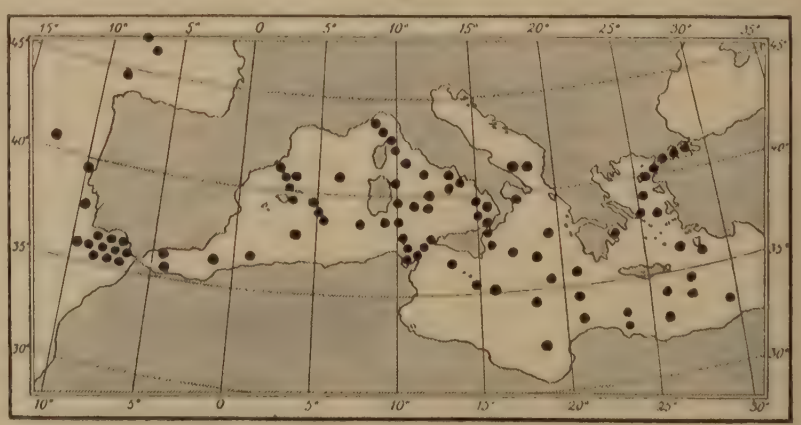

Chart 7. Scyllarus arctus, Phyllosoma-stages. Some stations lie outside the Chart to S.W.

It is found throughout the whole of the Mediterranean (as is the adult) from Gibraltar to Constantinople, and seems to be evenly distributed in both basins.

Season. The no. of spec. is not evenly distributed in regard to season. The winter hauls (Dec.—Febr.) only yielded 1.3—2.3 spec. per hour, the summer hauls on the other hand 4.8—17.9, with a marked maximum from 7—8 in June—July to 17.9 in August, falling again to 4.8 in Sept.

"Thor" 1908—10	Specimens	Duration of hauls in hours	Average no. of spec. pr. hour
Dec.	12	5.75	2.1
Jan.	12	9	1.3
Feb.	7	3	2.3
June	18	2.25	8
July	75	10.75	7
Aug.	273	15.25	17.9
Sept.	6	1.25	4.8

Dividing the various stages according to months, we find that in winter, only the older stages (5) 6—8 stage, were taken, whereas in summer, also the youngest were taken, the result in September, however, being already as in winter.

"Thor" 1908—10	No. of specimens, 1.—8. stage								
	1. st.	2. st.	3. st.	4. st.	5. st.	6. st.	7. st.	8. st.	total
Dec.	..	..	..	..	..	4	6	2	12
Jan.	..	..	..	..	1	6	3	2	12
Feb.	..	..	..	..	—	3	2	2	7
June	..	..	..	1	9	5	1	2	18
July	—	1	6	11	18	17	18	4	75
Aug.	2	7	17	47	58	76	55	11	273
Sept.	..	..	..	..	1	1	3	1	6

This seems to suggest that even though the species may propagate in winter, the summer is its chief spawning season, and that the metamorphoses must take place comparatively quickly, probably in the course of very few months.

This agrees very well with what we find in the literature as to females with ova. Pesta 1918 gives the spawning season as July, but Dohrn (l.c. 1870) who made his incubating experiments at Messina in winter, (1868—69) states that the fishermen brought him daily large quantities of specimens, "unter denen fast immer eiertragenden Weibchen sich fanden". Our Zool. Museum has a female with ova from Syracuse, taken May or June 1893.

No. of ova is stated as "sehr verschieden, erreicht aber niemals die grosse Masse der Palinuruseier". (Dohrn 1870 p. 251). The eggs are a golden yellow, 0,4 mm. diam. (Dohrn 1870, p. 251, Pl. 16, fig. 1—col. fig.).

Vertical occurence.

"Thor" 1908—10	No. of hauls			
	Night		Day	
	Winter	Summer	Winter	Summer
0— 25 m.w.	7	35	—	2
25—100 —	6	9	4	6
100—150 —	—	1	—	1
150—400 —	1	10	3	1
> 400 —	—	10	—	1
total	14	65	7	14

At night, it was taken in winter evenly distributed from surface to a depth answering to 100 m.w., in summer chiefly with 10—25 m.w. (35 out of a total 65 hauls). The few day hauls (21 in all) seem to show that it is taken both winter and summer chiefly with 65 m.w., i. e. not much deeper than at night.

B. Atlantic.

In the Atlantic, 74 spec. of the Phyllosoma stages were taken in all. The stations are distributed from the Bay of Biscay to near the Azores, most, however, in the Bay of Cadiz. In the Atlantic it seems to occur more or less as in the Mediterranean.

Summary.

The adult form, which is edible, lives more especially at 4—20 m. depth, being evidently rare deeper down, and seems to prefer a muddy bottom. Though females with ova may be met with all the year round, the summer is evidently their chief spawning season. From the egg there emerges a Phyllosoma, which in the course of probably only a few months passes through 9 stages; these stages live at the surface, or not far below (answering to 10—65 [100] m.w.) The Phyllosoma passes into the natant stage, which doubtless lives for a very short time pelagically, then turning hard-shelled, and sinking to the bottom, when it enters on the adult stage.

Distribution. (See Pesta 1918, p. 175).

1. Probably the whole of the Mediterranean, incl. Adriatic.

2. Atlantic from the Channel to the Azores and Canaries; southern N. America, Rio de Janeiro.

3. Pacific. Mazatlan in Mexico.

Genus Scyllarides Gill.

Scyllarides de Man 1916, p. 65 (list of all species).
— Pesta 1918, p. 169 (lit. and syn.).
— Bouvier 1917, p. 104.

?1. SCYLLARIDES LATUS Latr. (Fig. 25).

A. *The adult stage.*

Scyllarides latus de Man 1916, p. 65.
— — Pesta 1918, p. 169, textfig. 55 (lit. and syn.).
— — Bouvier 1917, p. 104 (lit. and syn.).

B. *Development* (Natant stage; Phyllosoma see below).

Pseudibacus Veranyi Guérin-Méneville, Notice sur un nouveau genre de Crustacés de la tribu des Scyllariens, découvert par M. Verany, aux environs de Nice; Revue et Mag. de Zool., ser. 2, vol. 7, 1855, p. 137—41, Pl. 5.
— Heller 1863, p. 198.
— Bouvier 1913, p. 1644—46.

Mediterranean.

St. 145. 1925 m. 32°38′ N, 19°02′ E. 25-7-1910. 300 m.w., 4^{10} am., 30 min. 1 spec. 4 mm. — **St. 297** ("Pangan"). > 2000 m. 33°10′ N, 25°35′ E. 25-6-1910. 28 m.w., 12^{00} pm., 30 min. 2 spec. 4—5 mm.

At the above-mentioned stations were taken 3 specimens in all of an unknown Scyllarid-Phyllosoma, at a stage of development roughly corresponding to stage 4 of *Scyllarus arctus*, which it altogether resembles greatly, save for the fact that the apical spines of the tail are so long as to render the tail itself bifid for half its length (see fig. 25); also, ant. 2 is nearly as long as ant. 1, and p. 4 is at the same stage of development as p. 3 but a little shorter.

Fig. 25. Phyllosoma of ?Scyllarides latus (St. 145, 1900, 300 m.w.). Abdomen etc.

Owing to the very long apical spines on the tail, this larva can hardly be identical with that of *Scyllarus arctus*, but since it is at any rate closely allied to this, and as no other species of the group of *Phyllosomæ laticaudatæ* but *Scyllarus arctus* and *Scyllarides latus* have ever been found in the Mediterranean, it must belong to the latter species.

Bouvier, l.c. has shown that *Pseudibacus Veranyi* is not an independent species, but only the natant stage of *Scyllarides latus*. *Pseudibacus* is only known from Sainte-Hospice, near Nice, in deep water (Guérin-Méneville), and from 39°49$^2/_3$′ N, 9°49′ E, 60 m. (Senna 1903, p. 341).

Distribution. 1. Mediterranean. This species, the "grosse Bärenkrebs" of the Mediterranean, is probably distributed throughout the whole of the Mediterranean (Carus) in shallow water (4—10 m.) among rocks, where it buries itself in the bottom, but is not nearly so numerous as the small *Scyllarus arctus*. In the Adriatic, it has only been found at a few localities (Pesta), but I have myself seen it in several fish-markets in Dalmatia.

2. Atlantic. Portugal; coasts and islands of West Africa, Azores, Cuba (Pesta).

3. Red Sea.

Genus Thenus Leach.

Thenus Bate 1888, p. 65 (lit.).
— de Man 1916, p. 66.

?1. THENUS ORIENTALIS (Tønder-Lund) Fabr. (Fig. 26).

Thenus orientalis Milne-Edwards, Règne Animal Pl. 45, fig. 2.
— — Bate 1888, p. 66 (lit.).
— — Babic, Thenus orientalis (Fabr.) in der Adria; Zool. Anzeiger, vol. 41, 1912 13, p. 273—74 (lit.).
— — Pesta 1918, p. 168, 458.

? St. 209. > 2000 m. 40°34′ N, 3°03′ E. 29-8-1910. 200 m.w., 7^{25} am. 1 larva, 7 mm.

At this station, the "Thor" took a single specimen of a Phyllosoma which must be referred to the group of *Phyllosomæ brevicaudes*, as defined by Richters (Richters 1873, p. 640 [separately, p. 8]) and must therefore be ascribed to the fam. *Scyllaridæ*. It cannot belong to the genus *Scyllarus* (+ *Scyllarides*) itself, as the larvæ of the two Mediterranean species belonging here are known (supra); consequently, it must belong to the *Ibacus-Thenus* group.

Of this group, only a single species has ever been found in the Mediterranean, viz. *Thenus orientalis*, which is said to have been taken (1 spec.) in the Adriatic at Fiume (Babic l.c.). Pesta, however, is disposed to regard this as due to error, e.g. in the locality marked on the

label, as it has never yet been found in the Mediterranean area, but only farther east (Red Sea, Indo Pacific).

The carapace of the head is pear-shaped, somewhat longer than it is broad. The thorax nearly as long as broad, with a notch in the posterior margin, in which the quite short abdomen is set. Eye-stalks long, thin,

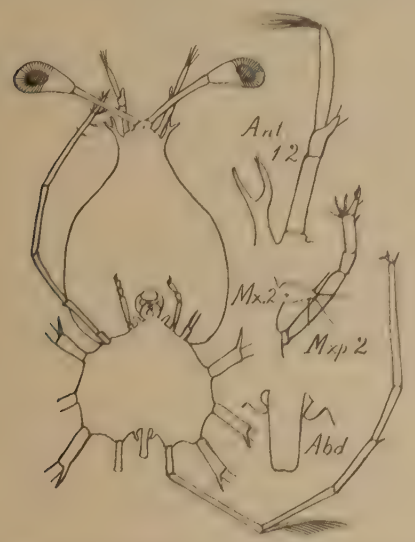

Fig. 26. Phyllosoma of ? Thenus orientalis.

articulated to the carapace. Ant. 1 as long as the eye-stalks, consisting of 3 joints, of which the distal is about as long as the two others together. Inner flagellum indicated but not articulated. Ant. 2 is formed by a small short fork, as long as 1. joint in ant. 1; the two rami are not articulated. Oral parts: nothing to remark save that they are as in *Scyllarus arctus* at the same stage; for the rest, see my detail figures of mx. 2 and mxp. 2. P. 1—4 completely developed and with natatory rami; dactyl rather short. P. 5 only abt. $^1/_2$ as long as the very short abdomen. The abdomen itself has neither pleopoda nor caudal fan; indications of plp., however, are discernible through the skin.

Fam. Palinuridæ Stebb.

Palinuridæ Gruvel, Ann. Inst. Océanogr. 3, 1911, p. 5.
— de Man 1916, p. 31 (list of all genera and species).
Pesta 1918, p. 165 (lit. and syn.).
— Bouvier 1917, p. 83.

On the species from the "Thor" area see above p. 68 (under Scyllaridea).

Genus Palinurus Fabr.

Palinurus Gruvel 1911, p. 16.
— Selbie 1914, p. 42.
— de Man 1916, p. 32 (list of all species).
— Pesta 1918, p. 165.
Bouvier 1917, p. 87 (key to species).

1. PALINURUS VULGARIS Latr.
(= P. ADRIATICUS Costa).

A. *Full grown stage.*

Palinurus vulgaris Gruvel 1911, p. 20.
Selbie 1914, p. 42.
— Pesta 1918, p. 166, textfig. (lit. and syn.).
Bouvier 1917, p. 89 (lit. and syn.).

B. *Development (Phyllosoma and Puerulus).*

Palinurus vulgaris Cunningham, On the Development of *Palinurus vulgaris*, the Rock Lobster or Sea Crayfish; Journ. Marine Biol. Assoc., vol. 2 (new ser.), 1891, p. 141—50, Pl. 8—9.
Bouvier, Recherches sur le Développement postembryonaire de la Langouste commune (*Palinurus vulgaris*); ibid., vol. 10, 1914, p. 179—93, 6 textfigs.
— Williamson 1915, p. 435—36, 2 textfigs.

Mediterranean.

St. 31. 1420 m. 41°44′ N, 10°52′ E. 22-1-1909. 65 m.w., 4^{30} am., 30 min. St. II. — **St. 39.** 1750 m. 39°41′ N, 10°02′ E. 1-2-1909. 65 m.w., 6^{10} am., 60 min. St. I, II. — **St. 58.** 85 m. 36°36′ N, 4°24′ W. 20-2-1909. 100 m.w., 2^{00} pm., 30 min. St. II. — **St. 59.** 1280 m. 36°02′ N, 4°24′ W. 21-2-1909. 100 m.w., 1^{40} am., 30 min. St. III. — **St. 282.** 200 m. 38°12′ N, 15°37′ E. 8-3-1911. 40 m.w., 8^{45} pm., 90 min. St. II. **St. 282.** ibid. 9-3-1911. 40 m.w., 3^{30} am., 90 min. St. II. **St. 283.** ibid. 12-3-1911. 40 m.w., 9^{30} pm., 180 min. St. II, III. — **St. 283.** ibid. 13-3-1911. 40 m.w., 0^{45} am., 180 min. St. V.

Atlantic.

St. 288. 105 m. 59°34′ N, 5°41′ W. 4-9-1904. 120 m.w. St. IX. — **St. 167.** Depth? 57°46′ N, 9°55′ W. 31-8-1905. 100 m.w. St. IX, 3 spec. — **St. 40.** 110 m. 43°23′ N, 2°02′ W. 11-5-1906. 100 m.w., 1^{15} pm., 30 min. St. I, 2 spec. — **St. 41.** 102 m. 43°23′ N, 2°01′ W. 14-5-1906. 15 m.w., 11^{00} pm., 120 min. St. I, III, V (2 spec.). — **St. 42.** 348 m. 43°31′ N, 2°13′ W. 15-5-1906. 15 m.w., 11^{35} am., 60 min. St. II, III (2 spec.), IV. — **St. 44.** 40 m. 43°58′ N, 1°27′ W. 16-5-1906. 50 m.w., 4^{00} pm., 30 min. St. VII. — **St. 190.** > 4000 m. 46°30′ N, 7°00′ W. 11-9-1906. 300 m.w., 3^{00} am., 120 min. St. IX. —

St. 70. 94 m. 39°06′ N, 9°47′ W. 4-3-1909. 65 m.w., 9^{00} am., 60 min. St. I (2 spec.), III. — **St. 73.** 180 m. 43°46′ N, 8°11′ W. 8-3-1909. 65 m.w., 3^{00} am., 30 min. St. I (4 spec.), II. — **St. 74.** 2000 m. 44°21′ N, 7°55′ W. 8-3-1909. 300 m.w., 10^{50} pm., 60 min. St. II. — **St. 75.** 4000 m. 45°37′ N, 7°03′ W. 9-3-1909. 300 m.w., 7^{45} pm., 60 min. St. I. — **St. 79.** > 150 m. 47°30′ N, 6°43′ W. 13-6-1910. 65 m.w., 8^{40} am., 15 min. St. II, V—VII (8 spec.) — **St. 80.** > 4000 m. 46°17′ N, 7°31′ W. 13-6-1910. 65 m.w., 10^{00} pm., 30 min. St. VII. — **St. 85.** > 700 m. 38°22′ N, 9°28′ W. 17-6-1910. 65 m.w., 2^{00} am., 15 min. St. VI.

The development of this species has recently been elucidated by Bouvier (l.c. 1914) with the aid of specimens from the Eddystone lighthouse; his work is unknown to Williamson (l. c.) who otherwise gives a survey of what was hitherto known. Cunningham had only the two first stages.

There are 10 Phyllosoma stages of from 3—21 mm.; the natant stage is 21 mm. All the spec. from the Eddystone were taken (by Cunningham and Bouvier) from latter half of June to abt. 1 Sept. the development seems to progress rather rapidly.

Depth to bottom for the larvæ within very wide limits, 40—over 4000 m. The adults, on the other hand, live largely at 60—70 m., in winter somewhat deeper (Pesta).

All the "Thor" spec. were taken near the surface, as a rule 15—100 m.w. and there is no essential difference between depths for day and night. Most of the Phyllosoma stages are represented in the "Thor" material, but not the Natant, which is extremely difficult to procure, as it doubtless hides among the stones on the bottom (Bouvier l.c., p. 191; Bouvier's specimen is indeed the only one known).

In the Atlantic (The Channel) Phyllosoma is found from latter half of June to abt. 1 Sept.; (Cunningham and Bouvier); the last stages are common, about end July and in August (Bouvier, p. 191). This agrees well with the "Thor" results, save for the fact that the first stages are taken as early as March; all the "Thor" spec. were taken between $38^1/_2{}^\circ$ and $47^1/_2{}^\circ$ N, except 4 taken $57^3/_4$—$59^1/_2{}^\circ$ N, i. e. north of the true area of the species. In the winter months proper the larva was not taken.

Atlantic. "Thor"	No. of larvæ (I—X = stages I—X)									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Mar.	7	2	1	—	—	—	—	—	..	—
May	3	1	2	1	2	—	1	—	—	—
June	—	1	—	—	2	4	4	—	—	—
Aug.	..	—	[illegible]	..	—	—	—	—	3	—
Sept. (4.-11.)	..	..	..	..	..	..	..	—	2	—

In the Mediterranean, on the other hand, we find a different state of things. All (there are, however, but few) were here taken in winter, from 22 Jan. to 13 March; in summer, or indeed outside the mentioned months, it was not found at all. Pesta (l.c.) gives the spawning time as spring, on towards May, and also August; as, however, he does not state the locality to which these seasons apply, the former should probably be taken valid for the Mediterranean, and the other for the Atlantic. Dohrn (1870) hatched it out at Messina in winter without further details given.

Distribution. 1. Mediterranean, very common.
2. E. Atlantic, from British waters to Cape Bojador.
See also Selbie, l.c. and Pesta, l.c.

Astacura Borradaile.

Astacura Borradaile, Ann. Mag. Nat. Hist., ser. 7, vol. 19, 1907 p. 475.
Homaridea Bouvier 1917, p. 9.

Nephropsidea Ortmann.

Nephropsidea Pesta 1918, p. 175 (lit. and syn.).

Fam. Nephropsidæ Stebb.

Nephropsidæ Stebbing, Hist. of Crustacea 1893, p. 201.
— de Man 1916, p. 95 (with list of all genera and species).
— Pesta 1918, p. 175 (lit.).
Homaridæ Bouvier 1917, p. 12 (key to the genera).

Of this family, only the three species taken by the "Thor" are known from the area here concerned.

One, *Nephropsis atlantica*, is a deep sea form, living at a depth of over 1000 m., and with colourless eyes; nothing is known as to its development.

The other two, however, belong almost exclusively to the littoral zone, and as they occur in great numbers are thus of economical importance, their life history is more or less well known. *Homarus vulgaris* is even supposed to be, with its near relative, *H. americanus*, the best investigated of all Evertebrata (Herrick 1909 [1911]).

Genus Nephropsis Wood-Mason.

Nephropsis Selbie 1914, p. 48 (lit.).
— de Man 1916, p. 97 (list of all species), p. 110.
— Bouvier 1917, p. 19 (key to the species).

1. NEPHROPSIS ATLANTICA Norman.

Nephropsis atlantica Selbie 1914, p. 48, Pl. 7 (lit.).
— — Bouvier 1917, p. 22, Pl. 1, fig. 1 (col. fig.), figs. 2—5.

St. 93. 1275—1180 m. 49°25′ N, 12°20′ W. 25-6-1905. 13 spec. 73—100 mm. — **St. 74.** 1200 m. 40°23′ N, 13°23′ W. 9-6-1906. 4 spec. 78—88 mm. (incl. 1 ♀ with ova 79 mm.).

This red species with colourless eyes lives at great depths especially 1200—1400 m.

Nothing is known as to its development. The ova from the ♀ taken by the "Thor" are 2.25 mm. diam. This spec. was taken in June; Selbie mentions (p. 4) females with ova as taken in Feb. and August; size of females with ova is 79—97 mm. (Selbie and "Thor").

It is evidently very common off S.W. Ireland; for the distribution (Atlantic, Indian Ocean) see H. J. Hansen 1908, p. 43, Selbie 1914, p. 52—53, and Bouvier 1917, p. 23.

Genus Nephrops Leach.

Nephrops de Man 1916, p. 96 (list of all species), 97.
— Pesta 1918, p. 182.
— Bouvier 1917, p. 17.

NEPHROPS NORVEGICUS L.

The adult stage.

Nephrops norvegicus Selbie 1914, p. 47 (lit.).
— — Pesta 1918, p. 183 (lit. and syn.), fig. 58.
— — Bouvier 1917, p. 18.

Development.

Nephrops norvegicus G. O. Sars, Bidrag til Kundskaben om Decapodernes Forvandlinger I; Archiv f. Math. og Naturvid., Christiania, 1884, p. 159, Pl. 1.
— — G. O. Sars, Bidrag ... II; ibid. 1889, p. 191, Pl. 7, fig. 27.
Astacus — Williamson 1915, p. 442, figs. 206—07.

Larvæ.

Mediterranean.

St. 35. 2000 m. 43°36′ N, 7°36′ E. 29-1-1909. 200 m.w., 6^{40} pm., 1 spec., stage III. — **St. 38.** 75 m. 40°45′ N, 9°50′ E. 31-1-1909. 25 m.w., 7^{10} pm., 30 min. 2 spec., st. I. — **St. 40.** 235 m. 39°10′ N, 9°40′ E. 1-2-1909. 65 m.w., 9^{30} pm., 30 min. 1 spec., st. I. — **St. 55.** 75 m. 36°46′ N, 2°18′ W. 19-2-1909. 25 m.w., 7^{40} am., 60 min. 3 spec., st. I—II. — **St. 58.** 85 m. 36°36′ N, 4°24′ W. 20-2-1909. 100 m.w., 2^{00} pm., 30 min. 5 spec., st. I—III.

Atlantic.

St. 62. 58 m. 35°45′ N, 5°59′ W. 21-2-1909. 100 m.w., 8^{30} pm., 30 min. 1 spec., stage III. — **St. 63.** 490 m. 35°50′ N, 6°03′ W. 22-2-1909. 600 m.w., 1^{45} am., 60 min. 1 spec., st. II. — **St. 40.** 110 m. 43°23′ N, 2°02′ W. 11-5-1906. 100 m.w., 1^{15} pm., 30 min. 1 spec., st. I. — **St. 68.** 550 m. 36°39′ N, 7°21′ W. 27-2-1909. 800 m.w., 5^{55} pm., 45 min. 1 spec., st. I. — **St. 73.** 180 m. 43°46′ N, 8°11′ W. 8-3-1909. 65 m.w., 3^{30} pm., 30 min. 5 spec., st. I—III.

The finding of the larvæ of this well-known species is of no interest save in as much as it shows that the larva is in the Mediterranean evidently only found in winter; none have ever been met with in summer. In the southern area of the Atlantic (Bay of Cadiz) the same would seems to apply, but in more northerly waters (abt. $43^1/_2°$ N) a single larva has also been taken in May off S.W. Ireland. Females with ova are found nearly all the year round (Selbie 1914, p. 4).

For the distribution (Atlantic from Iceland to Morocco, Mediterranean, Adriatic) see H. J. Hansen, 1908, p. 43, Selbie l. c., Bouvier 1917, p. 19, and Pesta l. c.

Genus Homarus H. M.-Edw.

Homarus H. Milne-Edwards 1837, p. 333.
Astacus Pesta 1918, p. 176 (lit. and syn.).

1. HOMARUS VULGARIS M.-Edw.

Homarus vulgaris Appellöf, Untersuchungen über den Hummer, mit besonderer Berücksichtigung seines Auftretens an den norwegischen Küsten. — Bergens Museums Skrifter, Ny Række, Bd. 1, Nr. 1, 1909 (with a long list of lit.).
Homarus gammarus, in Fr. H. Herrick, Natural History of the American Lobster; Bull. Bureau of Fisheries, Washington, vol. 29, 1909 (1911), Document No. 747 (bibliography on Homarus, p. 384—408).
Homarus vulgaris Selbie 1914, p. 53 (lit., distrib.).
Astacus gammarus Pesta 1918, p. 177 (lit. and syn.), fig. 57.

Development.

Homarus vulgaris G. O. Sars, Om Hummerens postembryonale Udvikling; Christiania Vid.-Selsk. Forhandlinger 1874, p. 1—26, Pl. 1—2.

Astacus gammarus Williamson 1915, p. 439, figs. 200—205.

Larvæ.

Atlantic.

St. 95. 74 m. 49°56′ N, 5°00′ W. 27-6-1906. 25 m.w. 2 spec., stage I. — **St. 43.** 1081—1650 m. 43°37′ N, 2°08′ W. 16-5-1906. 250 m.w. 1 spec., st. III. — **St. 195.** 170 m. 48°28′ N, 5°12′ W. 13-9-1906. 65 m.w. 1 spec., st. I.

III. APPENDIX.

I have here noted in a brief appendix a few species which are it is true outside the plan of the work, but on the other hand ought not to be omitted, since they present certain features of interest.

?GLYPHOCRANGON NOBILIS M.-Edw.

Glyphocrangon nobile A. Milne-Edwards 1881 (2), p. 5.
— — 1883, fig.
— *nobilis*(?) Faxon 1895, p. 142.

St. 178. 4000 m. 48°04′ N, 12°40′ W. 2-9-1906. 1800 m.w. 8 spec.: 2 ♀ with ova 90—96 mm., 6 spec. 57—73 mm.

The genus *Glyphocrangon* (*Rhachocharis*) comprises a number of species; see Milne-Edwards l. c., Smith 1882, p. 41, Bate 1888, p. 503, Faxon l.c., p. 137. For the literature see Stebbing 1910, p. 387.

The determination of the present specimens is not certain, as Milne-Edward's description is quite short, and I have not been able to compare with his figures l.c. 1883. I refer the specimens in question to this species partly (though in lesser degree) on account of their agreement with Faxon's description of a no. of specimens, though these again were not determined with certainty; partly, and more particularly, from some observations by Faxon, which would seem to show that *G. nobilis* differs chiefly from *G. longirostris* Smith (Smith 1882, p. 51, Pl. 5, fig. 1, Pl. 6, fig. 1) in the fact that the rostrum is no broader towards the point, and that *G. acuminata* Bate (Bate 1888, p. 522, Pl. 94, fig. 2—3) is possibly only a smooth form of *G. nobilis*; for both the two latter characters apply in a high degree to the present specimens. The largest specimen has, (in spirits) brownish eyes; in the others the eyes are colourless. All the specimens are now altogether colourless; but it is plainly evident that the oral parts and the tips of many of the spines were originally red. —

The genus *Glyphocrangon* is not new to the "Thor" area; Kemp 1910, p. 170, mentions a specimen of *G. longirostris* from S.W. Ireland, 900 fms. and Coutière, (1911, p. 156) a *G.* sp. taken at 36°—45° N, 11° W, but without further details.

Distribution (of *G. nobilis*): Dominica, West-Indies, 1 spec., 1131 fms. (Milne-Edwards l.c.). — Pacific Ocean: ??Gulf of Panama, 1270 fms.; Cocos Islands, 770—1067 fms.; from here to Malpelo Isl., 1132—1201 fms.; between Galera Point and Galapagos Isl., 1322 fms.; Galapagos Isl., 1189 fms., and from here to Acapulco, 1360 fms.; Acapulco 772 fms.; Gulf of California, 24° N, 995 fms. (totally 25 spec. from 11 stations; *G. nobilis*?, Faxon 1895).

PANDALUS (STYLOPANDALUS) RICHARDI Coutière.

Pandalus (*Stylopandalus*) *Richardi* Coutière 1905, p. 18, fig. 6.

Parapandalus Richardi de Man 1920, p. 108, 138, 140.

Atlantic.

St. 63. 490 m. 35°50′ N, 6°03′ W. 22-2-1909. 25 m.w., 0^{05} am., 30 min. 1 spec. abt. 28 mm. — **St. 65.** 1300 m. 35°53′ N, 7°26′ W. 24-2-1909. 1600 m.w., 0^{30} pm., 120 min. 3 spec.: 2 spec. abt 60 mm. (rostrum broken), 1 ♀ with ova 70 mm. — **St. 66.** 735 m. 36°16′ N, 6°52′ W. 25-2-1909. 65 m.w., 1^{45} am., 60 min. 1 spec. abt 40 mm. — **St. 66.** ibid. 300 m.w., 2^{55} am., 120 min. 2 spec. abt 33 mm. — **St. 66.** ibid. 1200 m.w., 8^{30} pm., 120 min. 1 spec. abt 40 mm. — **St. 69.** > 3500 m. 36°13′ N, 9°48′ W. 28-2-1909. 300 m.w., 11^{40} pm., 4 spec. 25—abt. 55 mm. — **St. 91.** 1225 m. 35°53′ N, 7°26′ W. 18-6-1910. 1600 m.w., 5^{25} pm., 60 min. 8 spec. 55—60 mm.

We have in the "Thor" material 20 specimens of this species, which has hitherto only been mentioned by COUTIÈRE (l.c.). Depth to bottom is 490—over 3500 m.; it was taken at night with 25, 65 and 300 m.w., by day with 1200 and 1600 m.w. All the stations are situate in the Bay of Cadiz, which brings the distribution right over to the coast of Europe; formerly, it was only known at some distance from Europe: 32°18′ N, 23°58′ W, 1000 and 2000 m.w.; 31°46′ N, 25°00′ W, 3000 m.w., and 27°43′ N, 18°28′ W, 3000 m.w. (COUTIÈRE l.c.).

ALPHEUS RUBER H. M.-Edw. (Fig. 27, Chart 8).

Adult stage.

Alpheus ruber Kemp, Ireland 1910, p. 120, Pl. 19, figs. 1—2.
— — Pesta 1918, p. 91 (lit.), fig. 30.

Larval development.

Diaphoropus sp. Lo Bianco 1904, p. 32, Pl. 11, fig. 41 (col. fig.)
Alpheus ruber Coutière 1907, p. 51, fig. 14 R, 18.
— Williamson 1915, p. 388, fig. 107.

Adult stage.

Mediterranean.

St. 18. 220 m. 37°51′ N, 23°14′ E. 30-12-1908. 1 spec. — **St. 27.** 90 m. 40°58′ N, 13°49′ E. 19-1-1910. 3 spec. — **St. 137.** 195 m. 37°17′ N, 10°56′ E. 19-7-1910. 3 spec. — **St. 140.** 112 m. 37°29′ N, 12°34′ E. 20-7-1910. 7 spec. — **St. 213.** 75 m. 40°14′ N, 0°54′ E. 31-8-1910. Abt. 35 spec.

Larvæ.

Mediterranean.

? St. 20. > 1300 m. 37°48′ N, 15°49′ E. 5-1-1909. 25 m.w. 1 spec. (defective). — **St. 21.** > 500 m. 37°51′ N, 15°21′ E. 5-1-1909. 10 m.w., 11^{50} pm. 1 spec. — **St. 118.** > 2700 m. 41°00′ N, 6°43′ E. 30-6-1910. 65 m.w., 11^{35} pm., 30 min. 1 spec. — **St. 123.** > 600 m. 44°14′ N, 8°55′ E. 3-7-1910. 10 m.w., 2^{30} am., 15 min. 13 spec. — **St. 123.** ibid., 25 m.w., 1^{50} am., 15 min. Abt. 25 spec., stage V—VII. — **St. 124.** 86 m. 44°20′ N, 9°05′ E. 3-7-1910. 65 m.w., 3^{30} am., 90 min. Abt. 50 spec. — **St. 126.** 600—620 m. 42°43′ N, 9°50′ E. 10-7-1910. 25 m.w., 10^{10} pm., 30 min. 10 spec. — **St. 126.** ibid. 300 m.w., 9^{30} pm., 30 min. 1 spec. — **St. 134.** 350 m. 37°37′ N, 10°17′ E. 15-7-1910. 25 m.w., 4^{50} am., 30 min. 7 spec. — **St. 139.** 600 m. 37°57′ N, 11°54′ E. 20-7-1910. 25 m.w., 1^{40} am., 30 min. 2 spec. — **St. 142.** 98 m. 35°44′ N, 15°07′ E. 22-7-1910. 25 m.w., 2^{50} am., 25 min. 4 spec. — **St. 142.** ibid. 150 m.w., 3^{40} am., 150 min. 4 spec. — **St. 143.** 1842 m. 35°18′ N, 16°25′ E. 23-7-1910. 25 m.w., 1^{20} am., 30 min. 3 spec. — **St. 171.** 50 m. 41°07′ N, 29°05′ E. 10-8-1910. 50 m.w., 3^{30} pm., 15 min. 1 spec. — **St. 174.** 120 m. 40°54′ N, 28°53′ E. 11-8-1910. 65 m.w., 11^{50} am., 30 min. 1 spec. — **St. 176.** 560 m. 40°45′ N, 27°43′ E. 12-8-1910. 65 m.w., 4^{00} am., 30 min. 2 spec. — **St. 179.** 85 m. 40°02′ N, 25°55′ E. 13-8-1910. 65 m.w., 2^{15} am., 30 min. 2 spec. — **St. 181.** 225 m. 38°49′ N, 25°09′ E. 13-8-1910. 65 m.w., 2^{55} pm., 15 min. 1 spec., st. I. — **St. 183.** 223 m. 37°52′ N, 23°09′ E. 16-8-1910. 65 m.w., 5^{10} pm., 15 min. 2 spec. — **St. 183.** ibid. 300 m.w., 4^{45} pm., 15 min. 1 spec. — **St. 190.** 360 m. 37°51′ N, 15°19′ E. 19-10-1910. 25 m.w., 8^{15} pm., 10 min. 12 spec. — **St. 192.** 650 m. 38°07′ N, 15°35′ E. 20-10-1910. 600 m.w., 10^{50} pm., 30 min. 10 spec. — **St. 194.** 1140 m. 38°33′ N, 15°29′ E. 21-8-1910. 1200 m.w., 6^{00} am., 30 min. 1 spec. — **St. 200.** 940 m. 39°18′ N, 10°11′ E. 26-8-1910. 25 m.w., 3^{45} am., 30 min. 3 spec. — **St. 206.** 2782 m. 39°32′ N, 5°15′ E. 28-8-1910. 1000 m.w., 1^{40} am., 45 min. 1 spec. — **St. 208.** 1600 m. 40°18′ N, 3°20′ E. 29-8-1910. 25 m.w., 1^{40} am., 15 min. 3 spec. — **St. 209.** > 2000 m. 40°34′ N, 3°03′ E. 28-8-1910. 150 m.w., 4^{25} am., 20 min. 3 spec. — **St. 210.** 775 m. 41°10′ N, 2°23′ E. 30-8-1910. 600 m.w., 3^{35} am., 30 min. 1 spec. — **St. 215.** 1050 m. 39°14′ N, 0°52′ E. 31-8-1910. 25 m.w., 9^{20} pm., 30 min. 1 spec. — **St. 276** ("Pangan"). > 3000 m. 36°30′ N, 19°20′ E. 4-4-1911. 132 m.w., 11^{55} pm., 35 min. 1 spec. — **St. 277** ("Pangan"). > 3000 m. 33°20′ N, 27°30′ E. 6-4-1911. 132 m.w., 11^{35} pm., 35 min. 3 spec. — **St. 340** ("Pangan"). > 2000 m. 35°50′ N, 21°30′ E. 26-8-1911. 28 m.w., 9^{00} pm. 1 spec. — **St. 340.** ibid. 108 m.w., 9^{00} pm., 30 min. 1 spec. — **St. 385** ("Pangan"). > 3000 m. 35°10′ N, 18°10′ E. 9-11-1910. 122 m.w., 9^{00} pm., 30 min. 1 spec. — **St. 410** ("Pangan"). > 1000 m. 37°12′ N, 1°18′ W. 29-12-1911. 112 m.w., 7^{00} pm., 30 min. 1 spec. — **St. 730** ("Nordboen"). > 1000 m. 38°36′ N, 13°37′ E. 16-4-1913. 2^{00} pm. 1 spec.

Atlantic.

St. 65. 1300 m. 35°53′ N, 7°26′ W. 24-2-1909. 600 m.w., 10^{00} am., 120 min. 2 spec. — **St. 376** ("Florida"). 34°41′ N, 16°14′ W. 22-7-1911. 15 m.w., 8^{45} pm., 30 min. 2 spec.

All that we know of the development of this species, of which WILLIAMSON 1915 has given a survey, is, that LO BIANCO (1904) found some larvæ which he hatched out to the adult species, but he gives no description, — and that COUTIÈRE (1907) has briefly described the larval stages he borrowed from LO BIANCO (but not the transition stages to the adult).

The larvæ in the "Thor" material agree very well with COUTIÈRE's description, and belong almost exclusively to the oldest stages (4.—6. stages); it is not altogether impossible, however, that they may belong to another species, for C.s description is very brief, and there are in the Mediterranean at least 4 other species of *Alpheidæ*, viz.: in addition to *Athanas nitescens* (whose larva is described in detail by G. O. SARS in Archiv f. Math. og Naturvid., Bd. 27, No. 10, Christiania 1906) also *Synalpheus lævimanus*, *Alpheus dentipes* and *A. megacheles* and the larvæ of these last three species are not yet known.

COUTIÈRE describes 6 stages of which even the youngest has free uropoda and articulation between telson and 6. caudal segment. The "Thor" (st. 225, 1910,

65 m.w.) has, however, taken a single specimen of a still younger stage, somewhat over 3 mm. long (fig. 27) (COUTIÈRE's "St. I" is 4 mm.). The telson is not separated as a distinct segment, and the uropoda can be seen through the skin lying in the very broad, triangular telson, which has on its posterior margin (incl. corners) the same 8 pairs of spines as in COUTIÈRE's stage 1; the only discrepancy in regard to these spines is that in COUTIÈRE's stage 1, spine No. 4 (from the middle) is considerably shorter than nos. 3 and 5 —6, whereas in the "Thor" spec. all the spines 3—6 are about the same length.

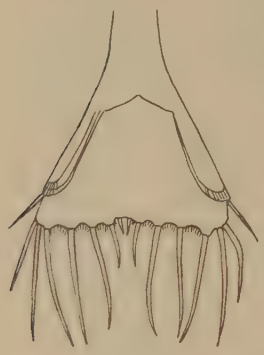

Fig. 27. Alpheus ruber. Telson of the youngest known larval stage. (St. 225. 1910, 65 m.w.).

As to the pereiopoda, nothing can be stated, as they are partly or entirely lacking in the specimen here considered.

The habitus-figure given by COUTIÈRE is better than LO BIANCO's fig.; p. 5 in particular is drawn too short by LO B. The stage shown must, from the development of the pleopoda, answer to stage 4 or 5. The largest larvæ from the "Thor" are abt. 9 mm., they have a small appendix interna on the inner ramus of the plp. and the telson is as in COUTIÈRE's 6. stage.

We have adult specimens from 5 st. in the Mediterranean; from the Balearic Isles to the Bay of Ægina.

The larva was taken at a no. of stations, evenly distributed from the coast of Spain to the Marmora. True, a great number of the specimens were taken over great depths to bottom, (up to over 3000 m.) but it will be seen from the chart that most of the stations are comparatively close in to land, and it is not remarkable that a pelagic organism should be found above relatively great depths to bottom, even though it may originate from places where the soundings are not very great (the adult appears to live especially at 50 80 m., rarely as deep as 200 m. or more).

Depths in m.	No. of stations
0— 500	9
> 500—1000	8
> 1000	14

About half the night hauls were made just at the surface, with 10—25 m. w., it is thus a surface form, as the colour (transparent with orange spots; see LO BIANCO's coloured fig.) also suggests; it was taken somewhat deeper in the daytime, only with 65 m.w., in the Mediterranean.

Nearly all the larvæ were found in the summer half year, June—Aug. only very few specimens were found outside this season; (Nov.—Jan., April). This agrees with PESTA's record (l.c.) of ♀ with ova (from the Adriatic) found in May and Sept.

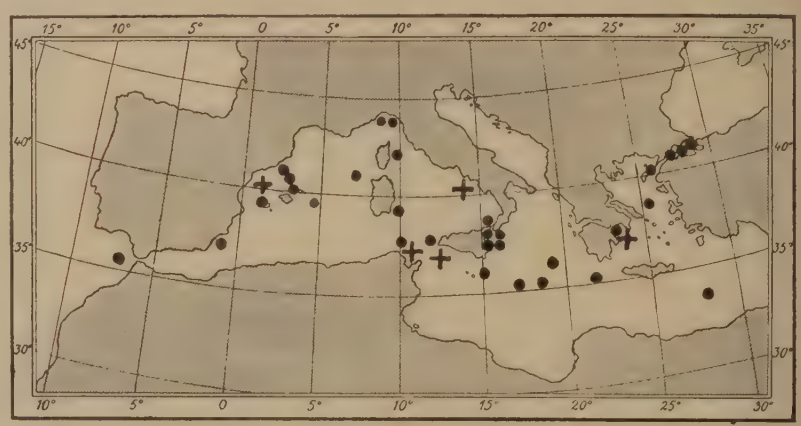

Chart 8. Alpheus ruber. + adult, • larvæ.

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REPORT ON THE DANISH OCEANOGRAPHICAL EXPEDITIONS 1908—10
TO THE MEDITERRANEAN AND ADJACENT SEAS
Vol. II. Biology.

J. 2.

Mediterranean Dinophysiaceae.

By

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Bergen's Museum, Bergen, Norway.

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I. INTRODUCTION.

While working upon the Ceratia material from the "Thor", (This Report, vol II, J 1) I also noted throughout the Dinophysiaceae occurring in the samples, as items for a later, more extensive work, but without actually contemplating a special account of the Mediterranean species. It seemed to me, however, that it might be of interest to publish the most important part of my notes now, as they may presumably be regarded as more or less complete as far as concerns the contents and occurrence of species. The principle failings are, a still incomplete knowledge of the distribution of the species in the oceans generally, and also the fact that circumstances did not permit revision of plankton samples during the compilation of the work.

II. THE SPECIES FOUND IN THE MATERIAL OF THE THOR.

DINOPHYSIACEAE Pavill.

Pavillard 1916 (p. 44).

Like Pavillard (l. c) and Kofoid a. Michener (1911 p. 268) I look upon this group of the *Peridiniales* Schütt as a separate family (*Dinophysidae* Kof. a. Michen.). The genera in question show so many characteristic features as to general constitution, fission and evolution, that they on the one hand keep closely together, and on the other are very well separated from the rest of the family of Peridiniaceae, to which they have been referred as a subfamily. In fact, no genus transitional between these two families is as yet known (to me).

PSEUDOPHALACROMA n. gen.

The least differentiated forms of the family are found in the earlier genus *Phalacroma* Stein, which comprises a number of species, agreeing on the whole very well in morphological respects, e. g. in the shape of the body. An exception is formed by the *Phalacroma nasutum* Stein, which is so different from the other species that I think it deserves the rank of a separate genus. I have only seen very few specimens and have partly confounded it with forms of *Phalacroma rotundatum*, so that I am not at present able to give an accurate description or figure of it, or quite reliable details of its distribution. Its chief characteristics, at the same time those of the proposed new genus, are the prolongation of the "longitudinal furrow" beyond the girdle for a considerable distance (about $^2/_3$ that from the girdle to the apex), where it shows a dilated rounded end, protected by a raised edge, which altogether calls to mind the apical pore in the *Peridiniaceae*. Also, the ventral "fin" along the left side of the longitudinal furrow, other-

wise so conspicuously developed and so constantly provided with three ribs uniformly appearing in all species at about the same levels, is here but little developed and seems to be destitute of ribs. Otherwise the genus corresponds to Phalacroma.

In establishing this new genus provisionally I hope to draw attention to the remarkable species in question, which might well deserve a thorough examination, where it occurs more frequently. It may perhaps be reduced to a subgenus, as I have seen traces of a similar prolongation — but only a very short one — to a pore-like end above the girdle also in rare cases in species of *Phalacroma*.

PSEUDOPHALACROMA NASUTUM (Stein) (Fig. 1).

Phalacroma nasutum Stein 1883 pl. 18 figs. 1—6.

Body in side view roundish, in shape like a broad *Phalacroma rotundatum* (Clap. et Lachm.) with a low and small epitheca and narrow ventral lists, scarcely reaching half way down the hypotheca. In ventral view elliptical with almost rounded ends. Structure of theca rather coarse, crowded, pit-like areoles.

Fig. 1. *Pseudophalacroma nasutum* (Stein), from the right side, $^{400}/_{1}$. St. 66. The structure is only shown on a small portion of the theca. (So also usually in the following figures.)

The peculiar thick "megacytical" stages, described by Pavillard (1916 pp. 45—52) seem to be common in this species. One such, from the Black Sea, had the following dimensions: length 49 μ, dorso-ventral diameter 44 μ, transdiameter 37 μ; epitheca (6 μ high) and ventral lists very little prominent.

This species on the whole looks like some cyste-like stage of *Phalacroma rotundatum*. Besides the mentioned occurrence in the Black Sea (st. 172, 17—50 m., singly) it was caught at st. 209, 945 m. wire (in the Catalonian Sea), a very heavy-structured individual, and during the winter-cruise at st. 66 in Bay of Cadiz. According to my notes it was most probably also found singly at sts. 26 and 31 in the Tyrrhenian Sea in winter, and at sts. 189, 945 m. wire, 194, surface and 1145 m. wire, 205, 206, 223, 1950 m. wire, 224 and 226 (i. e. near the Straits of Messina, in the Balearic, the Catalonian and the Alboran Seas in August).

Entz (1902) mentions it from the Adriatic (Quarnero, May). Oherwise it seems to have been overlooked.

Outside the Mediterranean I have seen it from the Tortugas (Florida Current), in July, from about midway between Ireland and Nova Scotia in April, and off the Norwegian Coast near Bergen (December 1901, 5—8 m. below the surface).

PHALACROMA Stein.

This genus, in morphological respects the least differentiated of the family, has proved to offer considerable difficulty as to the distinguishing of the species. As already remarked by Pavillard (1916), the occurrence of most of the species in the Mediterranean is merely sporadical, which also renders a thorough treatment of the genus in a systematical respect somewhat difficult. The following list and remarks are therefore only to be considered as a preliminary report, based upon my notes and slides, prepared during my examination of the Ceratia.

Sectio I. PARADINOPHYSIS n. sect.

Theca in side-view roundish, in ventral view more or less broadly elliptical; epitheca convex, $\pm$ prominent over the plane of the girdle, which does not break the evenly rounded contour. Structure of theca finely areolate, sometimes almost indistinct, usually finely pitted, rarely coarse. Longitudinal (left) fin at the lower end angular or acutely protracted. Colour usually hyaline or pale rose; (yellow) chromatophores rarely present.

Girdle lists, answering to their position near the apical pole, often somewhat obliquely set; the upper one not infrequently somewhat better developed than the lower, without distinct ribs.

More or less small species, occupying an intermediate position between the genera Phalacroma and Dinophysis.

The separation of the genus *Phalacroma* Stein from *Dinophysis* Ehrenberg seems to me to be somewhat arbitrary. Both genera are, however, natural ones, showing parallel forms; only there are intermediate connecting links, species which may equally well be referred to either of the two genera. Such a connecting link is formed by the "*Dinophysis rotundata*"-group — which does not coincide with my section *Paradinophysis*, proposed above. I think, however, that group of species will find their most natural position in the genus *Phalacroma*, where Kofoid has placed them.

As the main distinguishing features between the two genera in question — in the absense of any definite difference in structure of theca — I consider the more or less pronounced differentiation of the upper girdle list (in size, structure and direction) in *Dinophysis*, and the more or less conspicuous compression of the body in that genus, in contradistinction to the almost uniform development of both lists and the usually much thicker body in *Phalacroma*. Chromatophores are often wanting in the latter genus, whilst they are generally present in the former.

1. PHALACROMA ROTUNDATUM (Clap. et Lachm.) Kofoid a. Michener (Fig. 2 p. 7).

Kofoid a. Michener 1911 p. 290.

By the above name I designate a variable species, or perhaps a group of species, usually referred to the genus *Dinophysis*, but in many respects differing considerably from the other species of that genus. They are less strikingly compressed, have a more regularly rounded shape and usually a much finer structure, and are especially characterized by wanting a funnel-like upper girdle list, both lists being low and almost equally developed, but more or less distinctly oblique, not perpendicular to the surface as usual in *Phalacroma*. When alive these forms are seen to be rose-coloured or hyaline, not (or very seldom) provided with yellow chromatophores.

The forms in question vary in size, structure and somewhat in shape. I think we may at once exclude the very small ones and refer them to one or more separate species (see below). The true *Dinophysis rotundata* of Claparède is stated to have a coarse structure, in contradistinction to *D. laevis*, where no structure was seen (by Claparède). Without being able to decide this question finally at present I shall follow my earlier impression (see Jörgensen 1899 p. 32), when I proposed to reduce this *D. laevis* to a variety of *D. rotundata*. As to the variation in shape there exist forms with a relatively large convex epitheca, and others with a much smaller, less conspicuous one. The form var. *laevis* should answer to the latter case, which is true, both in regard to the northern and to the Mediterranean specimens; I have not, however, the impression that there also is a special northern form with a very coarse structure and at the same time a large epitheca, answering to the true *D. rotundata* Clap. I hope, however, soon to be able to give a more detailed account on the whole family.

The *Phalacroma Rudgei* Murray and Whitting (1899 p. 331, pl. 31 figs. 6 a, b) is perhaps only a thick, "megacytical" stage of *Phalacroma rotundatum* var. *laevis*. It was only found once by the authors near the Azores, and is otherwise mentioned from the North Sea, where *Phalacroma rotundatum* is frequent. The detection of these megacytical stages by Pavillard removes the necessity of distinguishing between thick and thin forms of the same species.

In the collections of the "Thor" *Phalacroma rotundatum* var. *laevis* proved to be distributed all the way from the Bay of Biscay in June (1910) to the Southern Levant — where it only seemed to be present below the surface — and back again to off Lisbon in September. It also occurred in the region of the fresher water from the Black Sea, from st. 167 before the Dardanelles almost everywhere (in small numbers) to the st. 172 in the Black Sea, 17—50 m. The form occurring here agrees on the whole rather

well with the northern form. This was also the case with that from the Bay of Biscay, while in the Mediterranean proper beside this form another was frequent, which differs in having the "longitudinal fin" broader and more acutely protracted at the lower end, which was supported by a stronger and often club-shaped spine. The structure of the theca always was visible, but more or less fine, consisting of small and often rather pale, pit-like areoles.

The species was in all caught at 15 among 37 Mediterranean stations in winter, as far as the Bay of Aegina (from the Straits of Gibraltar and the Bay of Cadiz) and at 30 of 102 stations in summer. Where deep water samples were taken the species was present at more than half the number of stations, partly both in the surface and beneath, partly only in deeper layers. In greater numbers I have only seen it in a sample from off Naples in January.

Megacytical stages were relatively frequent and often seen combined with fission (sts. 31, 33, 58; 116, 139, 134, 199, 216, 234, 246, i. e. in winter in the Tyrrhenian and the Alboran Seas, in summer in the Balearic and the Tyrrhenian, and off Lisbon and Brittany).

The species has been previously reported from Naples by Entz (1884, "*Dinophysis laevis*"), Klebs 1884 (*D. rotund.*), Daday 1888 ("*D. rot. laevis*") and Schröder 1900 (also *Phalacroma Rudgei* and *vastum* (?)), from the Adria by Entz (1902), Schröder 1911 (scarce, also present in the brackish region on the Dalmatian Coast) and Schiller (1912), and by Pavillard 1909 (var. *laevis*) and 1916 from the Golfe du Lion, where he finds it rather rare in spring and in summer, in February 1912, however, abundant, with different megacytical fission-stages.

Otherwise this (or these) species may be said to have a very wide distribution in the Northern Atlantic, to the Barent Sea (August) and between Norway and Greenland and the northern coast of Norway, at Karajakfjord (Greenland) and at the New Foundland Bank. In the North Sea it is frequent and penetrates in single specimens to the Gothland Deep in the Baltic. The same or nearly allied species I have also seen from scattered localities in the tropical and subtropical Atlantic, to about 30° S. east of Southern Brazil and west of Southern Africa, as well as from the Arabian Sea and off the south-west point of Australia.

2. PHALACROMA OVATUM (Clap. et Lachm.) (Fig. 3 p. 7).

Dinophysis ovata Claparède et Lachmann (1859 p. 409, pl. XX figs. 14, 15).

There are some small forms, related to the preceding species, generally of much the same shape, but only about half the size. One of these is *Dinophysis ovata* Clap. et Lachm., which occurs in the fjords near Bergen and is a pretty little species, easily recognizable but so small that it passes through the finest of the common plankton nets. I have taken it together with other small organisms by a special net, and know it as an inhabitant of the waters during and after the great "in-flow of diatoms" (see Jörgensen 1905 p. 88). It has a distinct structure of small pit-like areoles and is especially distinguished by a small antapical spine-like projection (or sometimes two). Probably it is identical with *D. apiculata* Meunier (1910, p. 62, pl. III fig. 49) from the Barent Sea.

A similar form occurs rarely in the Mediterranean: sts. 18 (Bay of Aegina, December), 28 (off Naples, January), 94 (Cadiz Bay, June), 126 (Tyrrhenian Sea, July) and 156, 250 m. wire (Levant, July), always singly.

There also exist related small forms with a finer or indistinct structure of theca and destitute of spines at the antapical end. In the Mediterranean such a form proved relatively frequent, but again only occuring singly or in very small numbers: sts. 26 and 31 (Tyrrhenian Sea, January), 189, 945 m. wire, and 194, surface and 1145 m. wire, 205, 206, 209, 945 m. wire, 223, 1950 m. wire, 224 and 226 (near the Straits of Messina, in the Balearic and in the Alboran Sea, August and September).

In this case we have most probably to deal with more than one species, as these forms differ notably in shape, situation of the girdle, structure and evolution of the longitudinal fin. Similar forms

are *Dinophysis rotundata* Schütt 1895 pl. I fig 5 and *D. semen* Meunier (l. c. p. 61, pl. III figs. 47, 48). Other forms I have seen from the Tortugas (Mexican Gulf) and the Benguela Current.

These small species look partly like species of *Phalacroma*, partly, however, they are much more like the usual species of *Dinophysis* than the true *Phalacroma rotundatum* (incl. *Dinophysis laevis*) and *Ph. ovatum*, having a somewhat funnel-like, but low, upper girdle list, protruding beyond a very low epitheca.

3. PHALACROMA PARVULUM (Schütt) (Fig. 4).

Ph. porodictyum var. *parvula* Schütt 1895 Pl. 2 fig. 13,a.

Among the many forms closely related to *Ph. rotundatum*, both in shape and size, is the present, which is distinguished by more regular shape, sail broader at the lower part, and distinct "*Porodictyum* structure" of both "pores" and "poroids". Theca in side view almost circular, somewhat longer than

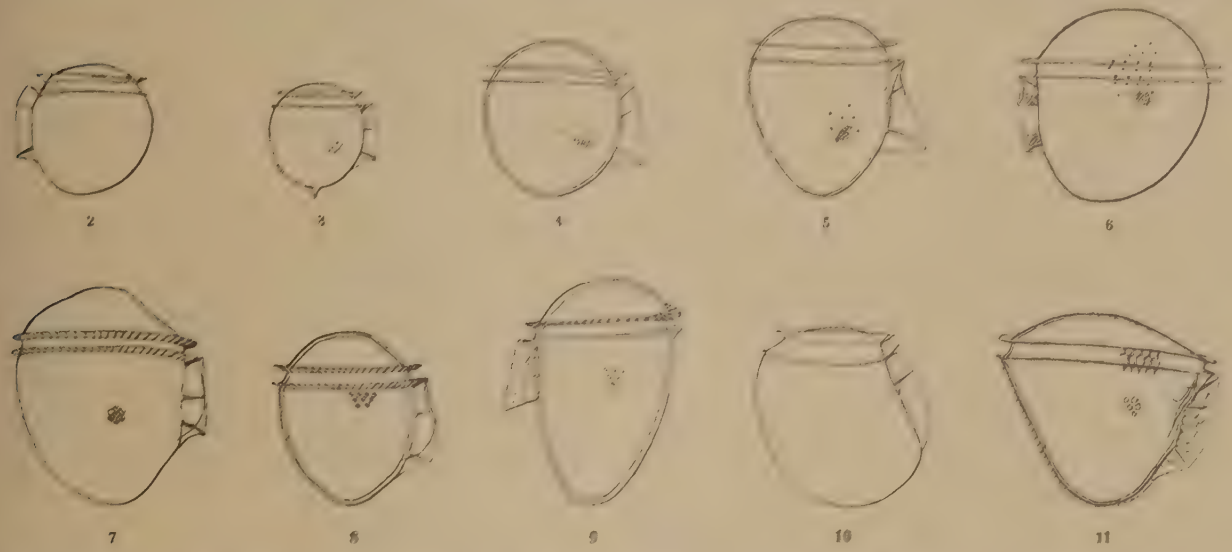


Fig. 2. *Phalacroma rotundatum* (Clap. & Lachm.) Kof., from the left side, $^{400}/_{1}$. St. 171. **Fig. 3.** *Phalacroma ovatum* (Clap. & Lachm.), $^{400}/_{1}$. Bergen 19. XII. 1903. Fig. 4 *Phalacroma parvulum* [illegible], $^{400}/_{1}$. St. 180 (345 m wire). Fig. 5 *Phalacroma operculoides* Schütt, $^{400}/_{1}$. St. 145. Fig. 6. *Phalacroma porodictyum* [illegible], $^{400}/_{1}$. Fig. 7 *Phalacroma operculatum* Stein, $^{400}/_{1}$. Deutsche Südpol-Expedition 11. VIII. 1903 (South Atlantic), 200 m. **Fig. 8.** *Phalacroma acutum* (Schütt) Pavill., $^{400}/_{1}$. St. 192. **Fig. 9.** Left half of theca of *Phalacroma elongatum* n. sp., $^{400}/_{1}$. St. 132 (from ship, seen on the upper girdle list). Fig. 10. *Phalacroma stenopterygium* n. sp., $^{400}/_{1}$. St. 205. **Fig. 11.** *Phalacroma cuneus* Schütt, $^{400}/_{1}$. Deutsche Südpol-Expedition, 21. IX. 1903 (Atlantic near the equator).

broad, with even contour hardly broken by the girdle; seen from above, the shape is broadly elliptical. Epitheca regularly dome-shaped, $^{1}/_{3}$ of total length; girdle lists equally developed, horizontal, low. The left longitudinal furrow list (the "sail") $^{2}/_{3}$ the length of the hypotheca, evenly broader towards the lower end, where it is cut off abruptly (transversely) with a somewhat acute outer angle. The lower (third) spine is thin and sharply pointed, pointing obliquely down; the middle (2nd, fission spine) directed outward and upward, and hardly $^{2}/_{3}$ as long. Distance between the two lowest spines twice that between the two upper ones. Structure of small areoles and regularly scattered (at same microscope adjustment) dark spots. Dimensions: Length 55—56 μ, breadth 51 μ, length of lowest spine 12 μ; diameter of girdle (*l'*) in side view 46—48 μ; breadth of theca seen from above 40 μ (?) all measured from four drawn specimens.

Without wishing here to go further into the nature of "pores" and "poroids" (Schütt) I would merely point out that the former are often difficult to see. Personally, they give me the impression only of being somewhat larger areoles, but they are distributed with a remarkable regularity, and provide what is usually an easily applicable mark of distinction.

Schütt does not state the degree of magnification for the figure referred to, so that I cannot with certainty see whether the dimensions fit my species; from the appearance of the whole figure, however, especially the breadth of the girdle, it would seem likely that this figure was drawn with the same magnification as fig. 13, 1—4, which would give a total length of 47 μ, i. e. somewhat smaller than above noted. The name chosen by Schütt also suggests a smaller form than the usual *Ph. porodictyum*.

I am unable at the moment to give its exact distribution in the Mediterranean, as it is so easily confused with *Ph. rotundata*, and on the other hand — from the structure of theca — with *Ph. porodictyum*. It was found, however, at many places, and appears to be frequent throughout the entire Mediterranean, though always in small numbers, which, however, may be ascribed to its smallness of size, on account of which it would be but incompletely taken by the nets. I have seen specimens from sts. 92 (Bay of Cadiz), 108 and 223 (Alboran Sea), 123 (Ligurian Sea), 126, and 200—80 m. at st. 199 (Tyrrhenian Sea), sts. 140 (Sidra Sea), 186 and 189, 945 m. wire (Ionian Sea), sts. 160 (Levant), 162 and 180 (Ægean) and 246 (w. of Brest). On the winter cruise it was taken at sts. 11 (Ionian Sea), 25 and 31 (Tyrrhenian Sea) and 45 (Balearic Sea). Entz (1902) notes it already from the Adriatic, and Ostenfeld and Schmidt (1901) from the Arabian Sea. Further, I have seen it from the German South Pole Expedition $^{11}/_{8}$ 1903, 200 m. (w. of South Africa) and $^{1}/_{10}$ 1903 (Guinea Current) also, alive, at the Tortugas, in the Mexican Gulf, May 1910 (colour pale rose, without chromatophores).

Sectio II. EUPHALACROMA n. sect.

Medium sized or rather large species, with structure of theca essentially as in the previous section, consisting of small areoles, forming regularly distributed spots (foveæ) or a fine, more or less regular network, often also with regularly distributed "pores". Theca in profile more or less narrowing downwards, from the ventral side, more or less wedge-shaped down, with broad, more or less domeshaped epitheca. Left longitudinal furrow list as in previous section, cut off sharply and acutely pointed below, but little if at all decurrent. Girdle lists equally developed and horizontal, with or without distinct ribs.

4. PHALACROMA OPERCULOIDES Schütt (Fig. 5).

Schütt 1895, pl. 2 fig. 11, 2, 3, (11, 1?).

Under this name, Schütt has figured (l. c.) two apparently different species. Unfortunately, his first figure is uncertain, and seems to represent the same species which he notes, lower down on the same plate, as *Phalacroma porodictyum* var. *parvulum*, while the second figure shows a characteristic species closely related to the foregoing, and possibly merging into the same. The shape of the body, however, is different — wedge-shaped as in most *Phalacroma* species — the epitheca, lower and broader, left longitudinal furrow list more drawn out below (broader), 3rd spine usually powerfully developed distally and the upper part of the longitudinal furrow list more or less bent over (rendering it often markedly narrower above than below). The dimensions somewhat larger, but otherwise proportionately about the same; total length 60—66 μ. Schütt presumably took them as distinct species chiefly on account of the structure, as he shows (fig. 11,1) this species without "pores", but I have found specimens, exactly corresponding to fig. 11,2, with the same structure as the foregoing species, with distinct pores. These are here pale, and often difficult to see except in empty thecae; with such, I was able clearly to discern that they are large, regularly distributed areoles.

All things considered, then, this last species is perhaps only a more or less accidental form of the first, in which case the name *Ph. parvulum* becomes superfluous. I shall, however, here provisionally retain the latter, in order to draw attention to the great similarity of the form in question to "*Dinophysis rotundata*", under which name it doubtless often occurs in plankton lists from the warmer seas. The form *Ph. operculoides* — Fig. 11,2 in Schütt, has as a rule been easily distinguished from the foregoing, *Ph.*

parvulum. The only "definite" difference, however, which I have been able to see as compared with the latter, is that the distance between 2nd and 3rd spines in the longitudinal furrow list is far less than twice the distance between 1st and 2nd.

It was fairly common in the "Thor" material, but occurred for the most part singly or in very small numbers in the samples from the summer cruise, st. 145 to st. 211: sts. 145, 147, 148 (Sidra Sea, July); 152, surface and 950 m. wire (Ionian Sea, July); 156, surface, 250 m. w., 158, 160 (Levant); 161, 163, 181, 182, 545 m. w., 183 (Ægean, August); 186, 245 m. w., 1145 m. w., 187, 945 m. w., 190, 192 surface and 545 m. w. (Ionian Sea, August); 194, surface, 199, 945 m. w., 200 (Tyrrhenian Sea, August); 209, 945 m. w., 210, 211 (Catalonian Sea, August). It was thus most frequent in the inner parts of the Mediterranean, here also in the Ægean, and in the Ionian Sea, at times several individuals together; after st. 211 I have not seen it. I do not venture to state anything definite as to its occurrence from st. 11 to st. 143.

Pavillard (1916) has already noted the species from the Mediterranean: Golfe du Lion, Sept., very rare.

5. PHALACROMA PORODICTYUM Stein (Fig. 6 p. 7).

Stein 1883, pl. 18 figs. 11—14, Schütt 1895 pl. 2, fig. 13, 1—5.

This species is larger than the two previous ones, in shape an intermediate form between the two, most like *Ph. operculoides*, but of characteristically oblique shape, with more or less ventral dislocation of the antapical pole. Epitheca highly domed and broad, approximately as in *Ph. parvulum*, hypotheca wedge-shaped, narrowing downward in profile and ventrally. The girdle lists are almost quite horizontal and equally developed, without or with faintly indicated transverse ribs. Left longitudinal furrow list short — 0.6 of the length of the hypotheca — and rather narrow, often somewhat bent over in the upper part, lower part not or but little broader, and here cut off obliquely (a little decurrent) with slightly acute or obtuse outer corner. Lower longitudinal furrow spine about same length as the middle one, moderately powerful development. Structure as in the two foregoing species. Colour, diffused rose.

Ph. porodictyum was already noted from the Mediterranean by Daday (1888) from Naples, and later by Schröder (1900) from the same locality, by Entz (1902) from the northern Adriatic, by Pavillard (1905) from the Étang du Thau (Decbr., very rare) and by Schröder (1906) from the "Ionian Sea" and (1911) northern Adriatic. Pavillard (1916) remarks that it is found throughout the year ("pérennant") in the Golfe du Lion, but is very rare.

On the winter cruise of the "Thor" it was found at sts. 10, 11, 26 and 39, and — according to my notes — probably also at sts. 16, 31 and 33, i. e. certainly in the Ionian and Tyrrhenian Seas, generally in very small numbers, at st. 31 and 33 somewhat more numerous. On the summer cruise it was taken in the Bay of Cadiz (sts. 91, 92, 95, June, and st. 231 Sept.) and of frequent occurrence generally, albeit in small numbers, throughout the entire Mediterranean as far as st. 161 (s. w. coast of Asia Minor) and st. 182, 545 m. w. (near Euboea) in August.

6. PHALACROMA OPERCULATUM Stein (p. p.) (Fig. 7 p. 7).

Stein 1883 pl. XVIII fig. 8 (not fig. 7).

Stein has figured two distinct forms under this name, fig. 7 and fig. 8. His fig. 7 shows a species greatly resembling *Ph. porodictyum* and differing only essentially in its more powerful structure, without the scattered "pores". According to my experience, this is only a form of *Ph. porodictyum* with a heavier structure, the scattered "pores" of which have become indistinct beside the other structure. Schütt (1895 pl. 2 fig. 10) shows the same, with the same characteristically oblique shape as in *Ph. porodictyum* (his fig. 13,8) only without "pores" and with closer set ribs in the girdle lists. His fig. 10,1, however, of *Ph.* "*oper-*

culatum" in fission, shows that the young theca has the scattered pores as in *Ph. porodictyum*. The colour of the cell, too, is the same as in this latter species.

With regard to my alteration of the specific name *operculatum* to denote STEIN's second figure, instead of the first, the text of the corresponding paragraph in the international botanical rules for nomenclature will be best met by considering fig. 7 as the true *Ph. operculatum*, including *Ph. porodictyum*, and giving fig. 8 a new name. As, however, *Ph. porodictyum* is a well characterised species and a well-chosen name, and STEIN has evidently intended *Ph. operculatum* to denote a similar species whose essential difference from the other was uniform structure without "pores", it seems to mé that the names might be retained with the slight alteration here suggested (always providing my conception of his fig. 7 proves correct).

My species, then, answers to STEIN's fig. 8, and differs from *Ph. porodictyum* chiefly in being less asymmetrical in structure, with slightly conical epitheca, distinct ribs in the girdle lists, and especially, a heavier structure of coarse, rather small areoles, forming a distinct reticulation with a "pore" in each areole. Dimensions approximately as in *Ph. porodictyum*, but somewhat larger; length of the specimen drawn 82 μ. As in *Ph. porodictyum*, the epitheca is high, and the left longitudinal fin not, or but little, broader below, here somewhat obliquely decurrent and generally obtuse-angled at the outer corner.

I am not certain whether this species is found in the Mediterranean, as my slides only contain forms answering to STEIN's fig. 7, and these proved not to be different from the foregoing species. I have, however, seen specimens from the German South Pole Expedition $^{11}/_{8}$ 1908, 200 m. (w. of South Africa).

Ph. operculatum is already noted from the Mediterranean (Adriatic) by STEIN (1883) and later by several writers. PAVILLAD (1916) records it from the Golfe du Lion (very rare, only in winter). In all these cases, the form concerned is probably one answering to STEIN's fig. 7.

7. PHALACROMA ACUTUM (Schütt) Pavillard (Fig. 8 p. 7).

Pavillard 1916 p. 55, pl. III, fig. 7, Ph. vastum var. acuta Schütt 1895 pl. 3, fig. 17, 1—4.

Related to the foregoing, but smaller, with coarse, but somewhat finer, often less distinctly reticulate structure, and markedly longer longitudinal furrow list, which is often also somewhat broader below. Length 60—65 μ, (SCHÜTT's and PAVILLARD's figs. 70 μ) longitudinal furrow list 0.8 of hypotheca's length. As in the foregoing, powerful ribs in the girdle lists. Theca often peculiarly obtusely pointed below, and of low conical form above, in ventral view, somewhat narrow, wedge-shaped.

This species is remarkably like *Phalacroma minutum* CLEVE (1900 p. 18 pl. 8, figs. 10, 11) and most probably identical therewith, though it appears larger as a rule. I have, however, seen specimens down to as low as 47 μ, and the forms in the Mediterranean seem generally to be smaller than stated by SCHÜTT and PAVILLARD. CLEVE's figure, however, represents an imperfect specimen, so that for the present, I consider it safest to retain the name as above.

It is altogether rare in the Mediterranean, but was taken both on the winter cruise (st. 31, Tyrrhenian Sea and st. 33 Ligurian Sea) and the summer cruise (st. 140, Sidra Sea, sts. 186, 189, 945 m. w., and 192, 545 m. w., Ionian Sea, and st. 206, Balearic Sea). Probably it is considerably more widely distributed than these few data show. I have also seen it from the Atlantic, about halfway between Madeira and Cape St. Vincent, (June 1906). CLEVE's species was found in the Gulf Stream, far to the south-east of Nova Scotia.

The species is already recorded for the Mediterranean by PAVILLARD (1916, Golfe du Lion).

8. PHALACROMA ELONGATUM n. sp. ad. int. (Fig. 9 p. 7).

This is a third species which is very closely related to the foregoing, also to *Ph. minutum* Cl. I have only seen two half-specimens, left half, in which the species showed marked resemblance to

CLEVE's figure of *Ph. minutum* (which likewise shows the left half of the theca). Possibly both, together with *Phalacroma acutum*, belong to one and the same, highly variable species — which would then presumably also include "*Phalacroma sp.*" OKAMURA 1907 (p. 134 pl. V, fig. 42 a—c) but while *Ph. minutum* Cl. represents one of the smallest forms, the present species is a larger one. It differs from the foregoing species chiefly in regard to shape, the rather low, domed epitheca, and the protracted, somewhat asymmetrical short-pointed hypotheca, which is, however, rounded off at the lower end. Girdle lists strongly developed, and with powerful transverse ribs, possibly also some reticulation; the left longitudinal furrow list also appears to have been long (and broad?) and likewise of powerful structure. Structure of theca strong, chiefly as previous species. Length 71—81 μ, breadth 48—50 μ.

This species may be identical with PAVILLARD's *Ph. acutum* which, from the figure, is 69 μ long. The shape in side view — PAVILLARD has only a figure from the dorsal side — is, however, very different from SCHÜTT's form.

St. 132, 600—195 m., s. e. of Sardinia, July.

Sectio III. CUNEUS.

Epitheca low. Cell markedly wedge-shaped, both in profile and in ventral view, greatest breadth and thickness at the girdle. Structure generally strong, more or less thick walled, but not very large reticulations. Colour in a live state (often?) diffused yellowish green. Girdle lists with irregular short ribs (innermost) which can on anastomose develope into an imperfect, coarse reticulation, or the one with short, regular radial transverse ribs. Left longitudinal furrow list longly decurrent at the lower end, arched below at the outer edge, with more or les markedly downward pointing lowest spine, the point of which lies far below the greatest breadth of the list.

9. PHALACROMA STENOPTERYGIUM n. sp. (Fig. 10 p. 7).

Remarkably like *Dinophysis sphærica* in several respects, especially in the left longitudinal furrow list.

Cell in profile irregular in shape, half roundish, half square, on the dorsal side and downward with almost smoothly rounded contour, on the ventral side almost straight or slightly concave, almost abruptly rounded off above; in dorsal view, more or less narrow wedge-shaped. Upper girdle list somewhat more developed than the lower, both without or with distinct short radial transverse ribs innermost by the cell. Epitheca flat, not or very little prominent, in side view considerably narrower than the hypotheca. Left longitudinal fin long and narrow, the lower end generally without supporting spine apparent, and here rounded off, or with a short spine soon disappearing outward. The cell 54—63 μ long, by 53—58 μ broad, (measured as usual perpendicularly to and parallel with the girdle); epitheca in profile 31—34 μ, 0.6 the breadth of the cell. Structure, distinct areoles or finer with scattered "pores".

Despite the great resemblance to the *Dinophysis* species, I have ascribed it to the genus *Phalacroma*, chiefly on account of the wedge-shaped cell and also because the lower girdle list can apparently have the same short radial ribs as the upper. It seems to be related to *Dinophysis expulsa* Kof. & Michener.

From the winter cruise of the "Thor" I have only seen it in samples from sts. 26 and 31 (Tyrrhenian Sea). On the summer cruise it was present at the following stations: 184,945 m. w. (?), 186 (in salpæ), 189, 945 m. w., 194, 0 m. and 1145 m. w., 204, 0 m., 205, 206, 0 m., 209, 945 m. w., 223, 224 and 226, i e. scattered throughout the whole of the Mediterranean to the Bay of Corinth, often in deep water samples.

10. PHALACROMA CUNEUS Schütt. (Fig. 11 p. 7).

Schütt 1895, pl. 3 fig. 14. Ph. Blackmani Murray & Whitting 1899 p. 330, pl. 31 fig. 4, a, b.

About as long (high) as broad in dorso-ventral direction, 72—88 μ, somewhat narrower in lateral direction, (perpendicularly to the median plane), seen from above broad oval. Especially the one girdle

list often with short, regularly set radial ribs. Left longitudinal fin rather broad, often with irregularly developed reticulation, more or less protracted downwards, rarely almost abrupt at the lower end, about $^3/_4$ the length of the hypotheca. The reticulation thin-walled, or somewhat thick-walled, on the epitheca generally with somewhat larger mesh than on the sides of the hypotheca.

An easily distinguishable species, widely distributed in the Atlantic. On the winter cruise of the "Thor" it was found at only 6 stations (Port Alice, 16, 18, 23, 24, 45) from the Bay of Ægina to Galita, only in single specimens. On the summer cruise it was found to be distributed from the south-west coast of Portugal (st. 234, 100—25 m.) to st. 182, 545 m., in the Ægean, now also rare and almost invariably in single specimens, generally only below the surface, but here present at lesser depths at nearly all stations where deep water samples were taken (sts. 126, 200—100 m., 275 m. w., 129, 80—0 m., 600—0 m., 1100—0 m., 134, 125—75 m., 152, 250 m. w., 156, 250 m. w., 182, 545 m. w., 186, 245 m. w., 187, 190—100 m., 945 m. w., 194, 1145 m. w., 199, 200—80 m., 945 m. w., 204, 945 m. w., 206, 1945 m. w., 209, 80—30 m., 100—85 m., 1945 m. w., 223, 1950 m. w., 234, 100—25 m.) whereas at the surface, it was only observed at four stations, (sts. 92, 183, 194 and 202). Sts. 199, 200—80 m., 209, 80—33 m., 129, 80—0 m. and 134, 125—75 m., in the central parts of the Mediterranean, were the only stations where several individuals were observed; otherwise, it was always but very sparsely present.

The species immigrates in all probability from the Atlantic, but presumably only to a slight extent. This immigration could not be directly traced at the time when the "Thor" samples were taken, — no immigration in January or September, and only insignificant traces in June — but may perhaps take place in the late autumn months. In the central Mediterranean, the species seems able to keep alive for some time in deeper water.

The species was already recorded from the Mediterranean by Schröder (from Naples) 1900 and later by Schröder (1906) ("Ionian Sea") and by Pavillard (1909 and 1916) from the Golfe du Lion ("all the year, but rare").

11. PHALACROMA STRIATUM Kofoid (Fig. 12 p. 13).

Kofoid 1907 a p. 195, pl. 12, fig. 73.

Resembles a large form of the foregoing, but with the hypotheca oblique and more broadly rounded below; is also particularly distinguishable by a very long and at the same time broad left longitudinal fin, the broad part of which reaches almost to the antapex, where it is shortly decurrent. The girdle lists often entirely covered with coarse reticulations. The lowest spine in the sail weak and directed downward or even at times somewhat rearward. The reticulation often faint and thin-walled; sail with more or less distinct structure of incomplete areoles, which often present the impression of irregular radial striations. Length of cell (height) almost equal to breadth in dorso-ventral direction, or somewhat greater; the latter 102—136 μ.

Very rare. Only observed at st. 187 in the Ionian Sea, singly in the sample from 190—100 m., and in the sample with 945 m. w. and at st. 126, 275 m. w. Kofoid found it in samples from the Pacific, n. e. and far to the s. w. of Galapagos. I have also seen it from the Guinea Current (German South Pole Exped. $^1/_{10}$ 1903, 200 m.).

Undoubtedly one of the tropical species which come in at times from the Atlantic through the Straits of Gibraltar, and are as a rule only found later on in deeper water in the inner parts of the Mediterranean, where they seem to be able to exist for a more or less considerable time.

Sectio IV. ARGUS.

Structure of theca reticulate, in large, thin-walled polygonal meshes, each with a pore in the centre. Cell almost elliptical in shape, somewhat wedge-shaped both in profile and in ventral view. Left longitudinal furrow list (fin, sail) essentially as in Sectio 3, with more or less indistinct lowest spine, the point of which lies far below the greatest breadth of the list. Girdle lists without regular radial ribs.

12. PHALACROMA ARGUS Stein (Fig. 13).

Stein 1883 pl. 18, figs. 15—17. Schütt 1895 pl. 3 figs. 15, 1—3.

The cell in profile somewhat asymmetrical elliptic (in relation to the girdle, which hardly breaks the contour). Epitheca almost evenly and highly domed, hypotheca obliquely oval, the ratio of their heights, reckoned vertically to the girdle, about 0.29. Girdle lists almost horizontal, parallel and strongly developed (breadth often somewhat exceeding that of the girdle) without transverse ribs; in specimens of more powerful structure, close into the cell, with irregular, coarse and short radial beams, finally anastomosing into an incomplete, wide-meshed reticulation. Left fin comparatively narrow, the upper part more or less markedly bent over, broadening evenly toward the lower end, and then rounding off in a curve to an

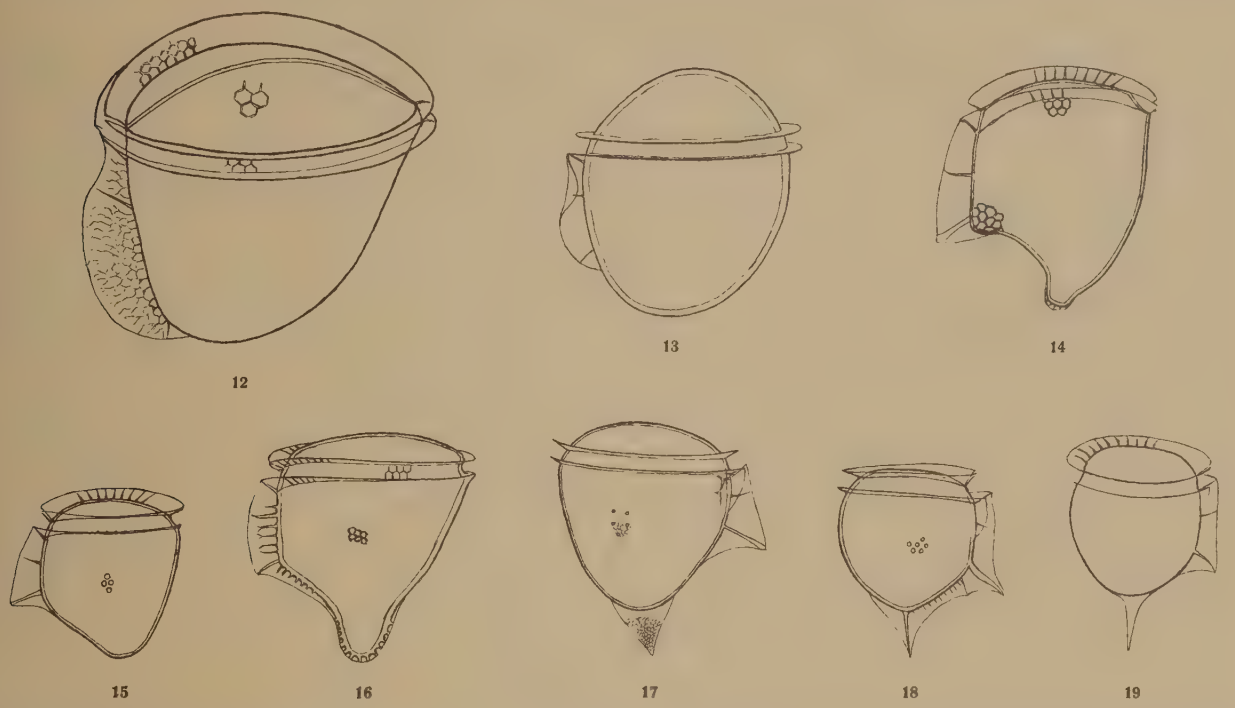


Fig. 12. *Phalacroma striatum* Kof., oblique side view, $^{400}/_{1}$. Deutsche Südpol-Expedition, 1. X. 1903 (Guinea Current). Fig. 13. *Phalacroma argus* Stein, $^{400}/_{1}$. St. 10. Structure of theca not shown. Fig. 14. *Phalacroma rapa* Stein, oblique side view, $^{400}/_{1}$. St. 66 (Cadiz Bay). Fig. 15. *Phalacroma dolichopterygium* Murr. & Whitt.?, $^{400}/_{1}$. Tortugas 4. VI. 1910. Fig. 16. *Phalacroma favus* Kof. & Michen.?, $^{400}/_{1}$. St. 10. Fig. 17. *Phalacroma doryphorum* Stein, $^{400}/_{1}$. St. 11. Fig. 18. *Phalacroma circumsutum* Karst., $^{400}/_{1}$. St. 156, 950 m. wire. Fig. 19. *Phalacroma pugiunculus* n. sp. ad int., oblique side view, $^{400}/_{1}$. St. 132.

obliquely decurrent lower part, without any angle at the outer corner. Structure of distinct pores, roughly distant one from another as the "pores" in *Ph. porodictyum* (but one in each mesh).

This easily distinguishable species was found on the winter cruise of the "Thor" throughout the whole of the Mediterranean (at 14 out of 37 stations), everywhere in single specimens, most rare in the Tyrrhenian Sea, in the Bay of Cadiz with "megacytic" cells. In the course of the summer cruise, it was found at 34 out of 102 stations in the Mediterranean, likewise in small numbers, or for the most part singly, again sparsely in the Tyrrhenian Sea, where it even appeared to be lacking in June, in the eastern Mediterranean almost exclusively in deep water. Megacytes in the Balearic and Catalonian Seas.

There was an immigration from the Atlantic in January and February, less in June, none in September. Appears to immigrate in winter, January to April; in the summer only a little during the earlier months. Was not found north of Cadiz. The species is already recorded for the Mediterranean by

Entz, 1902, from the northern Adriatic, and later by Pavillard from the Golfe du Lion, 1909 and 1916, (all the year round, most numerous in winter).

Also known from many places in the warmer Atlantic, including the Florida Current.

Sectio V. PODOPHALACROMA.

The cell, in ventral view, wedge-shaped, in profile irregularly so, more or less distinctly protracted downward into a broad rounded prolongation. Left longitudinal furrow list as in Sections I and II, structure as in Section III. In a living state, usually (?) coloured a diffuse yellowish green (?).

13. PHALACROMA RAPA Stein (Fig. 14 p. 13).

Stein 1883 pl. 19, figs. 5—8.

A comparatively large species. The epitheca flat, in profile hardly projecting beyond the girdle, seen from above, a broad oval. The hypotheca in profile with lateral contours almost parallel above, or converging downward, obliquely drawn out below at the back into a short rounded prolongation, on the ventral side abruptly ending in a broad obtuse angle. The girdle lists strongly developed, parallel and equally developed, directed slightly upward, with strong radial ribs. Left longitudinal fin about 0.6 of the length of the hypotheca, broad and often with some structure, in the lower part, broader, and almost transversely cut off to slightly decurrent, with slightly acute or almost rectangular outer corner, and long and powerful, obliquely down-pointing supporting spine. Structure coarse and very distinct, in large meshes with strong, but not thick walls, and distinct pore, one in each mesh. Length (height) of the cell 72—85 μ, breadth (greatest at the girdle) 60—64 μ. In a living state, diffused yellowish-green. (?)

An easily recognisable species, widely distributed throughout the Atlantic, according to Cleve (1901 a) from Lat. 20° S. to Lat. 42° N., Long. 1° E. to Long. 74° W. In the winter cruise of the "Thor" it was found scattered and very sparsely in the northern Ionian Sea (sts. 12 and 16) at st. 14 in the Adriatic, off Naples (sts. 25, 26, 28) in the Ligurian Sea (sts. 33 and 35), off the east coast of Sardinia (sts. 38 and 39), east of the Straits of Gibraltar (st. 60) and in the Bay of Cadiz (sts. 62 and 66), here, at one station (66) somewhat more numerous. On the summer cruise, it occurred from st. 89 off the south coast of Portugal sometimes numerous at the deeper outer stations (89, 91, 92) — here as the dominant species among the *Dinophysiaceæ* — sparsely at the inner stations (94—96) and later at most stations (54 out of 102) throughout the entire Mediterranean, as a rule singly or in small numbers. In the Sidra Sea it seemed to be lacking and was altogether most frequent and most numerous in the western part of the Mediterranean, west of the Tyrrhenian Sea, here, at stations along the coast of Africa and across to the south-eastern corner of Spain, on the way back, very numerous and dominant in September, but sparsely occurrent in June. Outside the Mediterranean, it was found on the return journey in the Bay of Cadiz at both stations, — also in deep water at st. 231 — in deep water at st. 234 off the south-west coast of Portugal and at sts. 237 and 238 (farther north), likewise at st. 243 (far to the south-west of Brittany), everywhere sparsely.

There appears to be an immigration of the species all the year round from the Atlantic. In the winter (December and January) it does not seem to survive the transition to Mediterranean water. In June, there seems to be an immigration with positive result, — albeit with a marked decrease in numbers on passing into the Alboran Sea — while the immigration in August appears to be excellently successful, with a striking increase in the number of individuals in the eastern part of the Alboran Sea and in the western waters of the Balearic Sea. Fission stages were observed.

Occurs at the Azores and in the Florida Current, and was noted from the Mediterranean already by Schröder (1900, from Naples) and later by Cleve (1903), Entz 1902, Zacharias (1906) and Pavillard (1915 and 1916, fairly frequent in the Golfe du Lion).

14. PHALACROMA DOLICHOPTERYGIUM Murray & Whitt.? (Fig. 15 p. 13).

Murray & Whitting 1899 p. 330, pl. 31, figs. 8, a, b. Ph. mitra Pavillard 1916 p. 53, fig. 13 B, p. 54 figs. 14 A—C, hardly Schütt 1895 pl. 4 figs. 18, 1—4.

Resembles the foregoing in shape, but is much smaller, with less coarse structure, not distinctly protracted — or off-set — antapical prolongation and the left longitudinal furrow list less broad below (though this is broader below than above). Epitheca somewhat domed, thus projecting slightly above the girdle in profile; dorsal contour of the hypotheca generally shows a smooth curve in the lower part, or but faintly off-set prolongation, this last, moreover, much broader in proportion than in *Ph. rapa*. Ventral side contour of the hypotheca is also less sharply (or angularly) truncated than in this last species. The cell seen from the dorsal side mainly as in *Ph. rapa*, but as a rule somewhat more compressed, and proportionately broader in side view. Length 60—68 μ, breadth 51—55 μ.

Ph. mitra Schütt seems, from the figure mentioned, to be *Ph. rapa*, but does not exhibit, in profile, the set-off lower prolongation. *Ph. mitra* (Murr. & Whitt. 1899 pl. 31 fig. 7) is doubtless *Ph. rapa*; it is stated in the text that they did not find Schütt's figure satisfactory, and therefore give a new one. Their *Ph. dolichopterygium* derives its name from the very long "wing" extending right to the antapex, but answers otherwise well enough to the species I indicate by the above name. They mention that it resembles *Ph. "mitra"* (i. e. *rapa*). Pavillard's species is doubtless the same as mine here (above) and it is in order to avoid a new name that I endeavour to use Murray and Whitting's (with essential correction for the "wing", which is roughly as in the foregoing species). The figure quoted by Pavillard as from Okamura looks to me as if it might be *Ph. rapa* (though the dorsal contour is not the same) while his fig. 42 is perhaps Pavillard's *Ph. mitra* (or perhaps *Ph. acutum*). The size of the figures and the structure seem to me safer distinguishing marks (than the dorsal contour and the antapical prolongation) in view of the obliquity of the cell, which may easily give rise to divergence in the drawings. I have indeed never seen anything quite corresponding to the long wing in Murray and Whitting's figure.

This species was found both on the winter cruise and the summer cruise of the "Thor", always singly or in small numbers. I cannot at the moment give any exact statement of its distribution, but have noted it on the winter cruise from st. 66 in the Bay of Cadiz, (several specimens), st. 55 off the south-east coast of Spain, and also from the northern Balearic Sea, the Ligurian Sea and the Tyrrhenian Sea. On the summer cruise, it was found scattered and sparsely, from the south-west coast of Portugal (at any rate in September) right in to the northern Ægean (st. 167) and even at st. 170 in the Sea of Marmora, 80—20 m., i. e. in the layer containing inflowing salt water from the Ægean. This species was also found in the Sidra Sea, at st. 145.

Outside the Mediterranean, I have seen it at the Tortugas, and in a sample from the Persian Gulf (more like Murray and Whitting's figure than usual). Cleve (1901 b and 1902) notes *Ph. dolichopterygium* from the Azores (in June), the southern Atlantic and the Indian Ocean.

15. PHALACROMA FAVUS Kof. a. Michener (?) (Fig. 16 p. 13).

Kofoid a. Michener 1911 p. 289. Ph. simulans Jørg. mscr.

In appearance, an intermediate form between *Ph. rapa* and *Ph. Hindmarchii* Murray & Whitting.

Epitheca low-domed. Hypotheca in the upper half in profile with almost straight converging lateral contours, below the middle, abruptly narrowed to a short rounded antapical prolongation, in shape and direction as in *Ph. rapa*, but situated almost in the middle, or somewhat nearer the dorsal side. Girdle lists as in *Ph. rapa*, Left longitudinal fin not or but little broader below, with distinct, but not particularly thickened lower supporting spine, pointing obliquely down, from here, longly and narrowly decurrent nearly to the base of the antapical prolongation. Structure rather coarse, somewhat finer than in *Ph. rapa*, but far coarser than in *Ph. Hindmarchii*. Two forms, a larger with length and breadth 81—83 $\mu \times 68$—71 μ, and a smaller, 54—62 $\times$ 54 μ.

I have not noticed that the species I have noted from the cruise of the Thor as *Ph. Hindmarchii* really differed essentially from that species. The few slides and figures I at present possess all exhibit the form here described, certainly, in two different sizes, but otherwise entirely alike in all essential characters. These are first and foremost, the development of left longitudinal fin which in the present species is but little broader at the lower supporting spine — this is not strikingly thickened distally — and from here longly decurrent, whereas in *Ph. Hindmarchii* it is drawn out into a much broader shape, with a club-shaped thickening of the supporting spine, and cut off almost transversely at the end, consequently much shorter. The outer corner, at the end of the spine referred to, is therefore, in *Ph. Hindmarchii*, acute-angled, (but the "point" itself blunt) or almost rectangular, whereas in *Ph. favus*, it is obtuse-angled. Furthermore, the lateral contours of the hypotheca in *Phalacroma Hindmarchii* in profile are convex and distinctly arched, whereas in *Ph. favus* they are straight and convergent. The antapical prolongation in *Ph. Hindmarchii* almost symmetrical — like the cell generally — whereas in *Ph. favus* it is more or less asymmetrical, with a somewhat ventral trend, much sharper set off from the ventral than from the dorsal contour. The structure in *Ph. Hindmarchii* also much finer, and the epitheca higher domed.

On the other hand, this species shows a close relationship to *Ph. rapa*, and this, moreover, to such a degree that there might be some grounds for regarding it as a variety of that species. It is particularly the longly decurrent left longitudinal fin, in connection with the medially placed end prolongation — giving a marked similarity of habitus to *Ph. Hindmarchii* — which makes me consider it necessary to note it as a distinct species.

This species has no resemblance to Murray and Whitting's figure referred to beyond the longly decurrent "sail". It seems, on the other hand, to be identical with the *Ph. favus* described by Kofoid and Michener; I have not, however, seen any figure of this latter species.

The certain specimens are from the winter cruise of the "Thor" st. 10 (Ionian Sea) and summer cruise st. 66 (Bay of Cadiz), here the smaller form, also with "megacyte".

Pavillard quotes (1916 p. 53) *Ph. Hindmarchii* as very rare from the Golfe du Lion, in winter samples. As no figure or description of appearance accompanies the statement, I cannot see whether this also is the above described *Ph. favus*. I have not noted either of the species at other stations than the two just mentioned.

Sectio VI. UROPHALACROMA.

Hypotheca furnished with a solid (not hollow) terminal spine, generally with ventral and dorsal lists. Cell in ventral view distinctly wedge-shaped, in side view, often less distinctly so, and always broadly rounded off below. The spine belongs only to the right half of the theca, (whereas the lower prolongation in the foregoing section is divided by the plane of fission). Structure fine, of small "poroids", with or without "pores".

16. PHALACROMA DORYPHORUM Stein (Fig. 17 p. 13).

Stein 1883 pl. 19, figs. 1—4.

A very characteristic and easily recognisable species. Epitheca low-domed, hypotheca oval wedge-shaped in side view, with medium long left longitudinal fin, broader at the lower end, here cut off almost transversely and very shortly decurrent, with slightly acute-angled outer corner and powerful, often distally thickened lower supporting spine. Apical spine more or less powerfully developed, in profile triangular of thin, broad sail lists (and more or less thick middle rib). The cell in profile is usually somewhat asymmetrical, with the antapical pole and the terminal spine displaced toward the ventral side. The cell wedge-shaped, compressed from the sides, seen from above an elliptical oval. Structure as in *Ph. porodictyum* with fine areoles and scattered "pores" (at a higher adjustment of the microscope), the areoles of unequal

size. The medial spine — the fission spine — generally very thin and very slightly conspicuous. Girdle lists equally developed, directed slightly upward, without transverse ribs. About 68 μ long, and 62 broad.

On the winter cruise of the "Thor" it was present at nearly all stations, generally in small numbers or singly, off Naples and the northern point of Corsica (sts. 26, 29 and 33) numerous, off the south-east side of Sardinia (sts. 40 and 42) and in the Bay of Cadiz, (st. 66), also in some quantity. On the summer cruise it was found from the Bay of Cadiz (rare in June) throughout the whole of the Mediterranean to st. 167, in the northern Ægean, in varying frequency. In the western part, the Alboran Sea and off the adjacent parts of the north coast of Africa, it was rare and sparsely met with, both in June and on the return voyage in September, otherwise occurring at nearly all stations, here and there numerous (the most numerously represented species of the Dinophysiaceae at sts. 115, 118, 123 (off Genoa, where it was numerous in July), 129, 0—80 m. and 0—1100 m, 134, 0—75 m. and 210 (Catalonian Sea, here very numerous). In the middle part of the Mediterranean it was constantly present below the surface; on the forward voyage it was found in the Tyrrhenian Sea exclusively below the surface and at all stations where such samples were taken. It was indeed found at all stations in the Mediterranean where deep water samples were taken. On the homeward voyage, in September, it was found at one station in the Bay of Cadiz, and the last time at st. 234 off the south-west coast of Portugal, here only below the surface, 100—25 m., sparsely.

The species must thus undoubtedly be indigenous to the Mediterranean, and seems to be numerous all the year round at certain places in the middle portion. There is also no doubt an occasional immigration from the Atlantic through the straits of Gibraltar, but this does not seem to play any great part. Fission stages were observed, at any rate at sts. 92, 109 and 119.

Recorded from the Mediterranean already by Pouchet 1883 (and Schröder 1900). According to Pavillard, 1916, the most frequently occurring *Phalacroma* species, in the Golfe du Lion, where it is found all the year round.

Outside the Mediterranean, the species is widely distributed in the Atlantic; according to Cleve, 1901 a, from 12° S to 57° N, and 9° W to 74° W. It is also found at the Azores and in the Florida Current.

17. PHALACROMA CIRCUMSUTUM Karst. (Fig. 18 p. 13).

Karsten 1907, pl. LIII fig. 8.

Very like the foregoing, and perhaps not altogether distinct from it in all its forms. The most essential difference is that the antapical spine and the lower supporting spine in the left longitudinal fin are joined by a more or less broad sail list. Also, the epitheca seems as a rule (in *Ph. circumsutum*) to be lower, the girdle lists often broader, and with an indication of transverse ribs close in the cell, which also is more laterally compressed. The structure of the theca may also be as in *Ph. doryphorum*, but seems often to be coarser, and without distinct scattered "pores".

Besides a larger form, answering to Karsten's figure, with protracted lower end of left longitudinal fin (at the supporting spine) and large, somewhat ventrally directed terminal spine, there occurred in the "Thor" material also a smaller and divergent form, with downward trending terminal spine, and slightly prominent corner of left longitudinal fin, shape of cell in profile broader in proportion, and epitheca higher.

Very rare in the "Thor" material, and only observed in samples from the summer cruise at sts. 156, 950 m. w. (Levant), 187, 945 m. w. (the smaller form) and 189, 945 m. w. (Ionian Sea), 194, 1145 m. w. (Tyrrhenian Sea), 206, 1945 m. w. (Balearic Sea) and 209, 1945 m. w. and 210 (the smaller form) in the Catalonian Sea. Found, then, only in one surface sample.

Karsten found the species in the Indian Ocean. I have also seen it in three samples from the German South-Pole Expedition, ($^{18}/_{9}$ 1903, $^{21}/_{9}$ 1903, 400 m. and $^{1}/_{10}$ 1903, 200 m., in and near the Guinea Current).

18. PHALACROMA PUGIUNCULUS n. sp. ad int. (Fig. 19 p. 13).

? Ph. pulchrum Kofoid a. Michener 1911 p. 291.

A smaller species with long, narrow terminal spine without (distinct) sail edges. The epitheca low-domed, the upper part somewhat flattened from above. Hypotheca in profile about symmetrical, $^2/_3$ of a circle, somewhat ovally extended downward. Left longitudinal fin long, somewhat broader below, and cut off almost transversely with acute outer corner and here almost a right angle with curving, down-turned, rather thin supporting spine. Girdle lists broad (especially the upper) and curved outward, with distinct but somewhat irregular radial stripes. Structure rather fine, of small areoles. Length and breadth 49—53 μ, by 43—48 μ.

Answers fairly well to the description of *Ph. pulchrum*, but differs in the transverse striation of the girdle lists.

Very rare, only observed in two summer samples, st. 132, 600—195 m., and st. 194 (southern Tyrrhenian Sea).

DINOPHYSIS Ehrb.

In contradistinction to *Phalacroma*, this genus, in its typical forms, includes more or less markedly compressed, not wedge-shaped species, with small or almost rudimentary epitheca and obliquely set girdle lists, which are more or less conspicuously dissimilar, the upper one being developed to a funnel, and often having a different structure (generally of radial ribs) from the lower. The section *Paradinophysis* of the genus *Phalacroma* connects the two genera, including as it does a continuous series of forms from those of the *Phalacroma* type — though not wedge-shaped — to those of the *Dinophysis* type, which latter have, on that account alone, been ascribed to *Phalacroma* as it would be unnatural to separate them from the others.

Both genera show a certain parallel development.

Sectio I. ACUTÆ Pavill. (emend.).

Theca in ventral view more or less narrowly elliptical to almost (broadly) linear, in profile irregularly pentagonal-ovate, somewhat tapering below, or rounded. "Funnel" (upper girdle list) without distinct radial ribs, left longitudinal fin long, about $^3/_4$ the length of the hypotheca.

1. DINOPHYSIS ACUTA Ehrenberg, Jörg. (Fig. 20 p. 20).

This species, which is very frequent in northern waters, was early recorded from the Mediterranean (Entz 1884, Daday 1888 etc.). As however there are two closely related species (see the two following) it was not until these were separated out by Pavillard (1909 and 1916) that we could take it for granted that records actually referred to the above species.

With regard to the name, it is no doubt most likely that Ehrenberg's original name was based on *Dinophysis norvegica* (from Kiel).

On the winter cruise of the "Thor" it was taken at 9 stations (11, 14, 23, 24, 25, 26, 28, 45, 53) from the Ionian Sea to the eastern part of the Alboran Sea, everywhere singly or very sparsely, most frequent off Naples. In the summer cruise it was found off the coast of Portugal in June (sts. 84, 85, 87) in September, several specimens off Lisbon and especially in the deep water outside (sts. 234, 235, 237), in June in the Bay of Cadiz (sts. 89, 92, Cadiz, — numerous, — 95) but not there in September, in the Straits of Gibraltar in June (st. 98) but lacking altogether in the Atlantic Current and indeed from Gibraltar to the coast of Tunis in July and from the Catalonian Sea to the Straits of Gibraltar in September. As regards the Western Mediterranean, on the inward voyage in July it is noted from 3 stations at the sur-

face (119, 120, 123) and from 3 stations only from deep water (sts. 126, 275 m. w., 132, 195—600 m., south east of Sardinia, and 134, 185—350 m. in the south eastern part of the Balearic Sea), on the return voyage in August, from several stations, three in the Tyrrhenian Sea (sts. 194, 0 m., 1145 m. w., 195, 199, 945 m. w., one in the Balearic Sea (st. 206, 1945 m. w.) and three in the Catalonian Sea (sts. 209, 33—80 m., 200—1000 m., 945 m. w., 1945 m. w., 210, 211) here numerous in deep water (945 m. w.) at st. 209, otherwise everywhere in small numbers. In the Eastern Mediterranean, it seemed to be lacking altogether in the southern part, and to be very rare generally, save in deep water between Greece and Sicily, where it was fonnd at all stations where samples were taken from deep water (sts. 161, 194, 945 m. w., 186, 1145 m. w., 187, 0—25 m., 945 m. w., 189, 945 m. w., everywhere single or few). On the other hand, it seems to be extremely numerous in the Black Sea, where, at st. 172, between 50 and 200 m., it occurred in quantities together with *Ceratium tripos* and *C. furca* (salinity about 20 ‰, temp. about 8° C.). In the intermediate area between the Black Sea and the Ægean, it was found in the Bosphorus and at Constantinople, also in the Marmora below the surface (sts. 170, 0—20 m., 20—80 m., 85—200 m., 195—1000 m., 175, 350 m. w., 1150 m. w., here many specimens with 350 m. w.). On the return voyage, it was found at Brest and outside (st. 246).

Outside the Mediterranean, it is widely distributed in the north-European waters (especially in the North Sea and Norwegian Sea), in the Atlantic from the most eastern parts at least to about 40° W, and south to abt. 48° N. (in April) or perhaps more southerly, along the coast of Portugal, as stated above from the "Thor" cruises in June right down to the Bay of Cadiz in September at any rate to south of Lisbon.

Immigration from the Atlantic does not succeed in June. Nor is there any distinct indication of immigration in September, but the occurrence at sts. 23—28 seems to be due to immigration through the Straits of Gibraltar in late autumn (Nov.?) and the occurrence at st. 45 — at the surface — must probably be ascribed to immigration in January; that at st. 134 — deep water — perhaps to immigration in the spring (May?). On the other hand, there may perhaps be a possibility of occasional emigration from the Black Sea region, and that the species can continue to exist at places with lower salinity or temperature. It appears to thrive in the vicinity of harbours; at Cadiz and Lisbon, for instance, it was numerous, and at Constantinople it was the only Dinophysiaceae species. Schröder (1911) found it below the surface off the coast of Dalmatia. It is perhaps altogether somewhat widely distributed throughout the middle and inner parts of the Mediterranean, in deeper water; the form there found is generally very thick-walled and of powerful structure (see fig. 20) and differs considerably in appearance from the northern form, though it cannot be reckoned as a distinct species. This seems to suggest that the species keeps alive for a long time in the Mediterranean, and should perhaps be regarded as indigenous (naturalised) there. (See also remarks to the three following species).

According to Pavillard (1916) in Golfe du Lion in spring and summer, sometimes numerous.

I have not seen it from the coast of America; the specimen noted by Cleve (1901 a) from the Florida Current, was probably the following species.

2. DINOPHYSIS INTERMEDIA Pavill. (Fig. 21 p. 20).

Pavillard 1916, p. 58, pl. III, fig. 4. D. atlantica Ehrb.? 1854.

Closely related to the foregoing, but differing in evenly curved dorsal contour rounded off below (in profile), somewhat narrower funnel base, generally somewhat less coarse structure with areoles of about equal size — in the foregoing species, they grow smaller in the circumference — and especially with a more compressed cell, with almost parallel lateral contours in dorsal view. In *Dinophysis acuta*, the cell, seen from the dorsal side, is generally narrowly elliptical, with convex lateral contours. Length and breadth (of cell, excl. funnel) reckoned vertically and parallel to girdle, about 64 μ by 49, as a rule somewhat shorter than the foregoing species.

On the winter cruise of the "Thor" this species seems to be lacking; only noted from st. 53 (singly). On the summer cruise, it was found at some few and scattered stations from the Straits of Gibraltar to the Ligurian Sea, the Bay of Corinth and the Levant; a couple of specimens also at st. 172 (Black Sea) 17—50 m, together with the foregoing species. In June, it was present at almost all stations in the Bay of Cadiz, for the most part singly, at st. 89 several specimens, in the Alboran Sea at 5 out of 10 stations, (sts. 98, 99, 102, 106, 109, generally very few specimens) in the Balearic Sea in June only at one station in the Atlantic Current (st. 113) and at st. 120 to the north, also below the surface, (185—350 m.) at st. 134 in the south-east, in the Ligurian Sea at st. 123 outside Genoa, in the Tyrrhenian Sea at st. 132 off the south-east corner of Sardinia and in deep water at st. 126 (275 m. w.) and 129 (0—600 m., and 0—1100 m.), in the Ionian Sea at st. 185 and otherwise only in deep water (sts. 152, 250 m. w., 184,

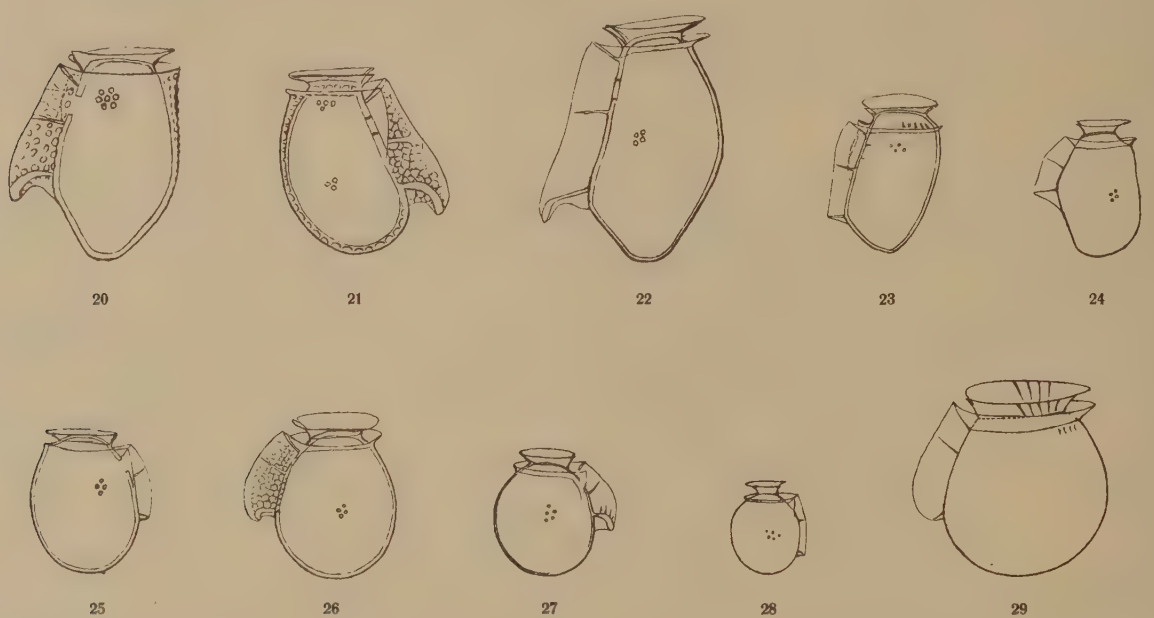


Fig. 20. *Dinophysis acuta* Ehrb., Jørg., *var. sculpta* n. var., $^{400}/_{1}$. St. 186, 1145 m. wire. Fig. 21. *Dinophysis intermedia* Pavill., *f. pachyderma*, $^{400}/_{1}$. St. 184, 945 m. wire. Fig. 22. *Dinophysis Schroederi* Pavill., $^{400}/_{1}$. St. 129. Fig. 23. *Dinophysis dens* Pavill., $^{400}/_{1}$. Cadiz. Fig. 24. *Dinophysis sacculus* Stein, $^{400}/_{1}$. St. 174. Fig. 25. *Dinophysis acuminata* Clap. & Lachm., *forma*, $^{400}/_{1}$. St. 53. Fig. 26. *Dinophysis ovum* Schütt, $^{400}/_{1}$. St. 45. Fig. 27. *Dinophysis lenticula* Pavill., $^{400}/_{1}$. St. 58, among diatoms. Fig. 28. *Dinophysis punctata* n. sp., $^{400}/_{1}$. St. 186, in salpæ. Fig. 29. *Dinophysis sphaerica* Stein, $^{400}/_{1}$. St. 45. (Only a few of the radial ribs of the upper girdle list shown in the figure.)

945 m. w., 186, 1145 m. w.) and in the Levant at st. 156, 250 m. w., 950 m. w. On the return voyage in the Western Mediterranean in August—September, it was present only at st. 202 (south coast of Sardinia) and 228, 1145 m. w. (east of the Straits of Gibraltar) and was further only observed at sts. 234—238 along the west coast of Portugal (234, 0 m., 0—25 m., 25—100 m., 95—200 m., 200—700 m., most specimens at depht 0—25 m.; 235, several specimens, Lisbon, numerous and altogether predominating over other dinophysiaceæ, 237, sparsely, 238 empty thecae).

There is a distinct immigration from the Atlantic in June, probably also in May, (and perhaps in late autumn). Fission stages were found in the Alboran Sea (sts. 99 and 109). Like many other Peridinea species it seems in the middle and eastern Mediterranean chiefly to go over into deeper water (in summer); if it really is present all the year round — as Pavillard thinks — it should presumably also be found at deeper levels in winter, which cannot be seen from the "Thor" material.

Outside the Mediterranean, I have seen it from the Florida Current, (off the northern coast of

Florida, temp. 23° C., $^{6}/_{5}$ 1910) and from several places, partly in mixed water, along the northern course of the Gulf Stream, far to the south of Nova Scotia, from 39° to 43° N, and 70°—40° W (temp. 22—18° C., salinity abt. 36.5 $^{0}/_{00}$).

3. DINOPHYSIS SCHROEDERI Pavill. (Fig. 22 p. 20).

Pavillard 1909, p. 284, fig. 5 (p. 283).

Very closely related to the two foregoing species, and particularly, it would seem, to *D. acuta*, from which it is at times hard to distinguish with certainty. It is more prolonged in proportion than either of these species, has in profile a more evenly rounded dorsal contour, than *D. acuta*, but less even than *D. intermedia*, is more broadly rounded below than the former, but less so than the latter, and is also in point of structure of theca an intermediate form between the two (which, however, do not differ greatly in this respect). The cell is markedly compressed, with lateral contours in dorsal view parallel or even slightly concave and the "funnel" in all essentials as in *D. intermedia*, somewhat higher, and narrower at the base, than in *D. acuta*.

Altogether, these three species are so alike that they are probably also closely connected genetically, presumably in a similar manner to the northern *Ceratium tripos* and the warm water species *C. pulchellum*. In other words, *D. intermedia* and *D. Schroederi* seem to me to be possibly warm water forms of *D. acuta*, or vice versa *D. acuta* a cold water form of the others. Despite the greater similarity between *D. acuta* and *D. Schroederi*, this latter seems in point of characters to be at least as nearly related to *D. intermedia*. I have also seen specimens (from the German South-Pole Expedition) which, I think, undoubtedly should be referred to *D. Schroederi*, but had the cell evenly rounded off below (in profile).

On the winter cruise of the "Thor", this species was found comparatively widely distributed in the Western Mediterranean, from the Bay of Cadiz (sts. 62, 66, 68) through the Alboran Sea (off the south coast of Spain, sts. 55—59) and in the Ligurian and Tyrrhenian Seas (sts. 29, 31, 33, 36, 38—42) but lacking off the coast of Africa. On the summer cruise, it seems on the contrary to be lacking altogether at the western stations, both in June and September, but was widely distributed in the Ligurian and Tyrrhenian Seas, sometimes only below the surface (sts. 123, 125, 126, 275 m. w., 128, 0—100 m., 129 at all depths, several specimens at 0—600 m., 132, 57—1090 m., 194, 1145 m. w., 197, 199, 945 m. w.) and in the middle and south-eastern parts of the Balearic Sea (sts. 137, 138, 202, 204, 206, 1945 m. w.) as also near Barcelona (st. 210 and Barcelona). Further, it was found at st. 140 in the western Sidra Sea, in deeper water to the south-east off the African coast (sts. 152 and 156, 250 and 950 m. w.), at st. 158 and in deeper water at two stations in the northern Ægean, (163, 0—80 m. and 182, 545 m. w.). Always in small numbers, most numerous in deep water at st. 129. West of a line Barcelona-Tunis I dit not observe it.

Outside the Mediterranean, I have seen the species from several places in the southern Atlantic, partly near and west of the southernmost part of Africa, (German South-Pole Expedition, $^{11}/_{7}$—$^{11}/_{8}$ 1903) partly east of South America ("Fram" 1911). Pavillard found the species in the Golfe du Lion (always rare, found more especially in winter). Schröder records it from the coast of Dalmatia.

From the "Thor"-material there is no direct sign of immigration from the Atlantic (as with the foregoing species) it seems therefore to be a true Mediterranean species (or form).

4. DINOPHYSIS DENS Pavill. (Fig. 23 p. 20).

Pavillard 1915, 1916, p. 57, pl. III, fig. 1.

I have only seen a few specimens from Cadiz, $^{19}/_{6}$ 1910. Pavillard found it in the Golfe du Lion in the spring.

A small form; the specimen drawn has a cell 51 μ long by 36 broad (measured as usual, vertically to and parallel with the girdle).

Being so small, it can naturally easily slip through the net; but not having seen it in the other samples, I should be inclined to think it must be neritic, and possibly a degenerate form (of *Dinophysis acuta*) as *D. diegensis* probably is of *D. caudata*. With it were found (at Cadiz) numerous *D. acuta* apparently in lively fission. I saw several young and small specimens, but do not venture definitely to assert that I saw transition forms to *D. dens*, as I did not realise the possibility of genetic connection until after I had handed over the material.

Sectio II. OVUM Pavill.

Theca in profile generally almost regularly oval or broadly ovate, broadly rounded below, or somewhat square-cut, at times with one or two processes or small spines (but no distinct terminal spine) in ventral view more or less broad with convex sides. Left longitudinal fin comparatively short, abt. 0.6 the length of the hypotheca. Otherwise as previous section.

5. DINOPHYSIS SACCULUS Stein (Fig. 24 p. 20).

Stein 1883, pl. XX, figs. 10—12. D. acuminata var. reniformis Pavillard 1905, p. 59, pl III, fig. 10. D. Pavillardii Schrøder 1906 p. 370. D. sacculus Pavillard 1916 p. 59 pl. II fig. 9.

The cell in profile broadly linear with almost straight, slightly concave or slightly convex dorsal contour and irregularly convex ventral contour, often swelling out a little medially, narrowing upwards, and small epitheca. "Funnel" and lower girdle list very prominent, not very broad; lower breadth of funnel (dorso-ventral diameter of epitheca) small, abt. 0.4 max. breadth of cell. Left longitudinal fin short and medium broad, cut off almost transversely below, with nearly rectangular outer corner and fairly strong but not long supporting spine.

A variable neritic species, length and breadth of cell 48—57 by 26—36 μ. Left longitudinal fin a little over half the length of the hypotheca.

I found it in the "Thor" material only from the Black Sea region, sts. 172, 0—17 m., 51—200 m. (empty), 174 (many specimens) and 175, at surface, singly everywhere save at st. 174 (Marmora).

Pavillard (1905) found it in the Étang du Thau and Golfe du Lion (here all the year round, sometimes numerous, fission stages in July according to Pavillard 1916). Schrøder found it in the northern Adriatic.

The species is noted by Cleve (1901 a) from 40—42° N, 10—9° W, (west coast of Portugal), and 1902 from 24—20° S, 4—0° E. He regards it (1901 a) as neritic.

6. DINOPHYSIS ACUMINATA Clap. & Lachm. (Fig. 25 p. 20).

Claparède & Lachmann 1859 p. 408 pl. 20 fig. 17.

Very like the following, but cell narrower, less egg-shaped with "funnel" lower and broader at the base (broader epitheca). Is often easily recognisable by a small point or process below, near the ventral side, often two or more in succession; I have not seen them in the next species.

Seems very rare in the Mediterranean. In the "Thor" samples I have seen it from sts. 53, 84, 87, Cadiz, 101, 235 and 246, i. e. only from the Alboran Sea (53 and 101) and west of there, where it was found on the return voyage in Septemper right up to beyond Brest (246). Very widely distributed in our northern waters.

7. DINOPHYSIS OVUM Schütt (Fig. 26 p. 20).

Schütt 1895, pl. 1, figs. 6, 1-9. Pavillard 1916 p. 58, pl. III.

Somewhat like a small *D. intermedia*, but with shorter (left) longitudinal fin, still smaller epitheca, less straight (slightly convex) ventral contour in lateral view and thick cell, not compressed, (as in *D. intermedium*). Length and breadth of cell: 47—54 μ, 40—47 μ, dorso-ventral diam. of epitheca abt. $^1/_3$ the maximal breadth of the cell. Structure rather coarse.

I found it in the "Thor" material from the winter cruise in samples from sts. 14, 26, 31, 33, 45 and 53, and in the material from the summer cruise from sts. 145, 161, 181, 206, 1945 m. w., Barcelona, 216, and 231; at the surface, always singly or few. It thus occurs rarely and scattered through the whole of the Mediterranean, summer and winter. Probably immigrates from the Atlantic, perhaps in winter.

First recorded from the Mediterranean by PAVILLARD 1905 (from Étang du Thau, where very rare in Decr.) CLEVE (1901 a) records it from 4 places in the Atlantic but it is doubtful whether these really refer to SCHÜTT's species.

8. DINOPHYSIS LENTICULA Pavill. (Fig. 27 p. 20).

Pavillard 1916 p. 59, pl. III, fig. 6.

A small species with more or less thick lenticular cell abt. 40 by 34 μ, or somewhat larger. Structure of rather coarse, pit-like areoles. Left longitudinal fin short and medium broad, often sharply bent over (to the right). Upper girdle list medium high, without distinct transverse ribs, dorso-ventral diameter at base (breadth of epitheca) $^1/_3$ or somewhat less, of maximal breadth of cell.

PAVILLARD found it in the Golfe du Lion, fairly frequent in Febr.-May. I have seen specimens corresponding in size in the "Thor" material from st. 58, (s. coast of Spain February); also noted (doubtful) from st. 187, 945 m. w.

9. DINOPHYSIS PUNCTATA n. sp. ad. int. (Fig. 28 p. 20).

Resembles the foregoing, but is smaller, with longer left longitudinal fin, still smaller epitheca and fine punctate structure. Also much like *D. "sphærica"* STEIN 1883 pl. XX, figs. 9 and 8, with structure as fig. 7, but without (distinctly) striped "funnel". Cell 28 × 23 μ.

I have seen it in material from salpæ, taken at st. 186 (northern Ionian Sea).

There seem altogether to be several quite tiny *Dinophysis* species which cannot be satisfactorily studied in samples taken with the usual plankton nets. This species is mentioned here, partly on account of its agreement with STEIN's figure, and partly because it may perhaps be a form of the foregoing. The *Dinophysis* species seem to have a somewhat large extent of variation.

Sectio III. SPHAERICAE Pavill.

Specially distinguished by radial ribs in the upper girdle list, (which is of medium height and breadth) and by having, in profile, an apparently almost ligulate and rounded lower end of the left longitudinal fin, without distinct supporting spine. Fine areole structure, generally with scattered "pores". Otherwise as previous section.

10. DINOPHYSIS SPHAERICA Stein, Schütt (Fig. 29 p. 20).

Stein 1883 p. p., pl. XX, figs. 3, 4. Schütt 1895, pl. I, fig. 7. Pavillard 1916 p. 60.

The cell in profile characteristically ovate roundish and slightly asymmetrical. Otherwise somewhat resembling *Phalacroma rotundatum*, but is easily distinguished from this by the higher, distinctly striated "funnel", and especially by the lack of the lower, in *Ph. rotundatum* strong, supporting spine, which in *Din. spaerica* is usually indistinct, or only distinct for a short inner portion, not as in *Ph. rotundatum*, running right out to an outer acute corner of the longitudinal fin.

STEIN's figures show the customary acute form of the outer corner of the longitudinal fin, with complete supporting spine, (as in *Phalacroma rotundatum*). It will be found, however, that this left longitudinal fin is markedly curved (to the right). I have seen a specimen, in somewhat slanting position, which showed almost the same appearance as STEIN's fig. 3, so that I think this figure answers to a slightly ventral profile position; the shape of the cell, too, then becomes as in STEIN's figure (less broad). The "funnel" too, suggests the same position of the cell.

Length and breadth of the cell as a rule 57—60 μ, by 55—57 μ, measured vertical to and parallel with the girdle. Structure as in *Phalacroma porodictyum*.

This species was apparently very rare on the winter cruise; I found it only from the two stations 45 (African coast) and 66 (Bay of Cadiz) singly. On the summer cruise, it was found to be widely distributed in the Western Mediterranean, but seemed to be lacking in the Eastern, (possibly one specimen at st. 163 off the coast of Asia-Minor, 0—80 m.; it disappeared during preparation). On the inward voyage, it was first noted at st. 118 in the northern Balearic Sea, and was further found at the following stations: 134, 0—75 m., 196 (?), 199, 945 m. w., 200, 204, at the surface, 205, 206, 0 m., 1945 m. w., 209, 1945 m. w., 210, 215, 216, 217, 218 (numerous), 219, 220, 221, 223, 1950 m. w. (numerous), 224 (numerous), 226, 228, at the surface, Gibraltar, 231, 1145 m. w. It was thus continuously present from st. 215 in the western Balearic Sea all the way to st. 231 in the Bay of Cadiz (not recorded only from sts. 225 and 227) and here at several places more or less numerous, while up to and including st. 204 it occurred only singly or in very small numbers. At five of the stations it was found only in samples from deep water; at st. 206 there were also many specimens, both at the surface and in the deep water sample (1945 m. w.). This distribution suggests that the species immigrates from the Atlantic in summer and multiplies in the Western Mediterranean, where it can sometimes also pass the winter.

It is already recorded from the Mediterranean by Daday, (1888) (Naples) and Entz 1902 (northern Adriatic). Pavillard (1916) finds it rare and sparsely occurring in the Golfe du Lion, but at all seasons. I have seen it from the Guinea Current ($^1/_{10}$ 1903, German South-Pole Expedition, 200 m.).

It is easily confused with *Phalacroma stenopterygium*, which has a similar (left) longitudinal fin, only narrower, low upper girdle list with short, incomplete but strong transverse ribs close in to the cell, and, in profile, wedge-shaped cell and somewhat differently shaped hypotheca.

Sectio IV. HOMUNCULUS Pavill.

Theca markedly compressed, with a more or less off-set broad tail-like antapical prolongation, at times also with a similar one more or less developed dorsally. Epitheca little developed, not projecting beyond the strongly developed upper girdle list, which in well-developed specimens is furnished with strong radial ribs. Left longitudinal fin powerfully developed, long, lowest (3rd) supporting spine likewise. Coarse areole structure.

11. DINOPHYSIS CAUDATA Kent (Figs. 30—34 p. 26).

Kent 1882 (p. 460). D. geminatum Pouchet (1883). D. homunculus Stein (1883) p. p. (pl. XXI, figs. 1, 2, 5, 7 not 3, 4, 8).

This common species of warmer seas was at first reported from the Mediterranean by Kent, who described specimens from the Adriatic under the above name, but without figuring them. Shortly afterwards the same species was excellently figured and described by Stein as *D. homunculus* (yet including the two following species), and so the older name was forgotten. The only one who has mentioned it seems to be Grenfell (1887), when describing his supposedly new species *D. semicarinata* (from Jamaica), which however is the present species.

Pouchet (1883) figured a pair of two cells — still cohering dorsally after fission, analogous to the chains of the Ceratia — under the name of *D. geminatum*, which also has the priority as a specific name before that of Stein, and can hardly be abandoned on account of its unfitting special form.

Gourret (1883) described this species from Marseilles under two different names, *D. Allieri* (p. 79, pl. 3 figs. 54, 54 a) and *D. inaequalis* (p. 80, pl. 1 fig. 21). The former figure really is a good one, the latter, however, like so many of his figures on pl. 1, but inadequate and so different from the other that he has deemed it necessary to keep them separate. Unfortunately, the description of this latter "species" also seems to have been made from this bad figure, not from nature, so that the supposedly distinguishing

marks are of no real value. He notes *D. Allieri* as frequent at Marseilles (while *D. inaequalis* is said to be rare).

Later on the species has been mentioned from Venice by Imhof (1886, 1891), from Naples by Daday (1888) and others, and from the western part of the Alboran Sea in October 1902 by Cleve (1903). Pavillard (1905) found it to be very rare in the Étang du Thau June—July and October—December, and (1909, 1916) very frequent in the Golfe du Lion.

Dinophysis caudata is a very variable species, also in the Mediterranean, partly on account of the immigration of various forms, partly because the species itself is undoubtedly a very plastic one, being able to adapt itself to very extensive changes of the hydrographical conditions, especially as to salinity of the water.

At present I should propose to try to collect the various forms under two principal varieties, the *var. Allieri* (Gourr.) Lemm. and the *var. abbreviata* nov. nom., to which, outside the Mediterranean, is to be added the *var. pedunculata* Schmidt (1901 p. 221), from the Indian Ocean. The former variety, which might be considered the typical form of the species, is a relatively slender form, chiefly characterized by a very broad longitudinal fin, protracted below, and a relatively long and narrow process (prolongation). The fin makes about half the length of the body (processus included, but "funnel" above excluded) and decidedly more than half of its breadth, usually nearly two thirds of it. The breadth of the process at its upper broader end is much less than that of the fin at the level of the lower — third — rib or spine, which is elegantly curved in its distal half. Reticulations of the fin usually very conspicuous, while the intermediate (second) rib is rather obscure. The "funnel" is large and conspicuously striate.

A special form of this *α Allieri* is represented in fig. 30 p. 26, as *f. speciosa*. It answers very well to Stein's figures 1, 2, except that the process in these figures is straight (directed along the axis of the body), while in my figure it is oblique. Similar forms with a nearly straight prolongation do occur in the Mediterranean, but only exceptionally.

Gourret's figure of *C. Allieri* shows the distinctive marks of this typical form, except at the lower end of the fin. I have therefore used Gourret's name (see below about young specimens).

The typical form of Pavillard (1916 p. 56 fig. 15 A) diverges a little towards the next variety — in regard to the shape of the body and, especially, as to the breadth of the fin, which is only half that of the body — but answers to my form in the length of the fin.

The type of Schröder (1911 p. 36 fig. 7 b) looks at first quite different — compare Pavillard l. c. p. 57 — but may nevertheless also belong here, as it answers to *α Allieri* in the best distinguishing mark, the length of the fin, as well as in the general shape of the body and the development of the "funnel"; it wants, however, the characteristic lower part of the fin, which is also too narrow, and it has a less distinctly defined process. Stein's fig. 5, also of a specimen from the Adriatic, deviates in a similar manner, but seems to show that also this form — under a special denomination — may be included under *α Allieri*. I have myself met with similar forms from the Eastern Mediterranean in summer.

The other variety, *var. abbreviata*, has a broader body with a shorter and broader process, a relatively longer, but narrower fin, extending beyond the middle of the body and provided with a stronger intermediate rib. The breadth of the fin in its lower part is only half that of the body, or a little less, and but little more than the breadth of the process at its upper end.

Fig. 31 p. 26 shows a better developed specimen of this variety. The lower end of the fin is less protracted than in *α Allieri*, but otherwise similar. The process is more abruptly set off from the body at the ventral side.

Beside this form, which still recalls to mind the typical one, there exist a series of others, which distinctly lead over to smaller forms with much less distinctly developed characters of the main species. The end of the series is constituted by the *var. ventricosa* Pavill. (see fig. 32) and *Dinophysis diegensis* Kof., which is scarcely to be separated with certainty from *D. caudata*, in spite of its strikingly different appearance.

Fig. 33, *f. Marmarae n. f.*, is a form from the inner region of the Aegean Sea — where the fresher water from the Sea of Marmora exercises its influence — and from the Dardanelles and the Marmora. The length of the longitudinal fin is about $^2/_3$ of the length of body, and the breadth less than half the breadth of the latter. The "funnel" is still well developed and distinctly striate, the process abruptly set off and the fin conspicuously reticulate. Fig. 34, *f. pontica, n. f.*, from the Bosphorus and the Black Sea is, however, considerably modified, though still distinctly allied to the preceding form. It possesses a similar broad and large fin, but a process, much less abruptly set off, and a less developed funnel, which shows no distinct striae. The size also is somewhat reduced.

Fig. 32 is the end form of the series, still more reduced in size and deviating in the same manner as the preceding form, only in a more marked degree. Also the longitudinal fin has become much nar-

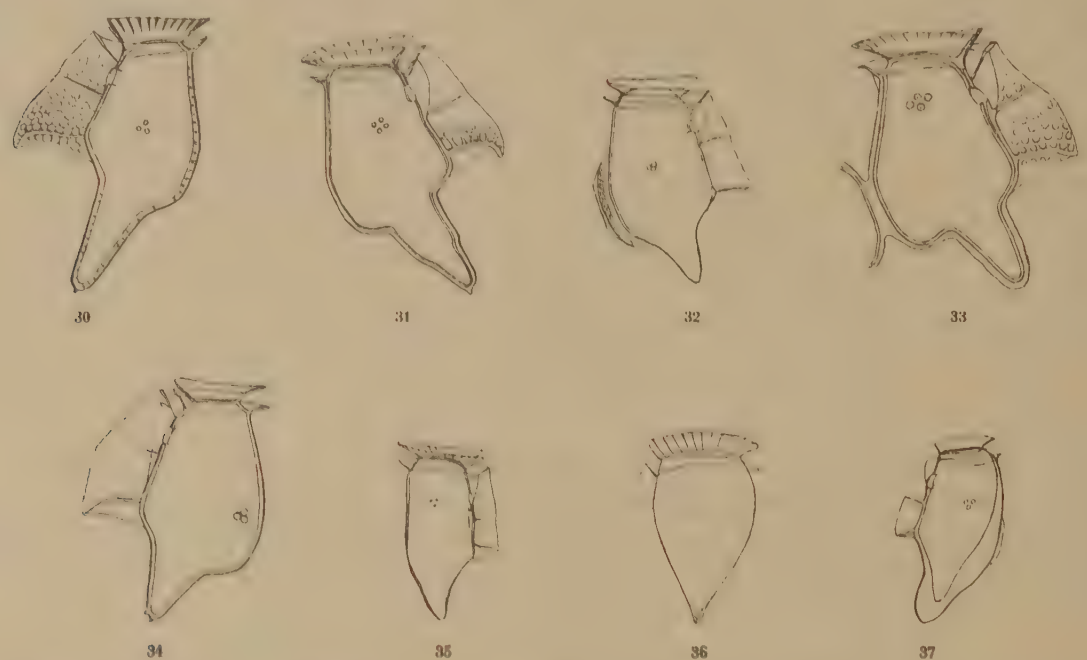


Fig. 30. *Dinophysis caudata* Kent, *a Allieri* (Gourr.), *f. speciosa*, $^{400}/_1$. St. 123. Fig. 31. *Dinophysis caudata* Kent, *var. abbreviata n. var.*, $^{400}/_1$. Malaga Roads. Fig. 32. *Dinophysis caudata* Kent, *var. ventricosa* Pavill., $^{400}/_1$. Lisbon. Fig. 33. *Dinophysis caudata* Kent, *fo. Marmarae*, after fission, $^{400}/_1$. St. 165. Fig. 134. *Dinophysis caudata* Kent, *fo. pontica*, $^{400}/_1$. Bosphorus. Fig. 35. *Dinophysis caudata* Kent, *var. subdiegensis* n. var., $^{400}/_1$. St. 60. Fig. 36. *Dinophysis diegensis* Kof. (?), left half of theca, $^{400}/_1$. St. 66. Fig. 37. *Dinophysis caudata* Kent, a degenerate form, after fission, $^{400}/_1$. Coast of Arabia near Ras Dschibsch, 20. X. 1910, Handel-Mazzetti.

rower, only amounting to one third of the breadth of body; the curvature of the lower spine and the reticulations of the fin are here wanting. Younger specimens generally show a feebler development of the characteristics of the lower part of the fin (a less protracted end, a less curved spine and feebler reticulations) and of the "funnel" (smaller and more or less obscurely striate).

The last mentioned end form (fig. 32) in my opinion clearly proves to be a degenerate form of the main species.

On the winter cruise of the "Thor" *Dinophysis caudata* was present everywhere, but generally scarce or even in single specimens. Relatively more numerous it was at some of the western stations in the Alboran Sea and in the Cadiz Bay.

In summer it was not met with in June until near Cape San Vincent (st. 87), but was thence forward almost continuously present all the way through the Mediterranean and back again in September, when it followed up to near Cape Finisterre (st. 238), and also appeared singly southwest of Brittany (st.

245). On the route outwards in June it was ± scarce, now and then even wanting, but from the Tyrrhenian Sea plentiful or even abundant at most stations, also in the South-eastern Balearic and the Western Sidra Sea, where it was especially numerous between Tunis and Sicily. Also in the Eastern Mediterranean it was everywhere present and often numerous, here and there even very abundant (optima at st. 164 off Asia Minor and at st. 189 off the south-west point of Italy, where it occurred in very great numbers). In the region influenced by the fresher water from the Black Sea it was remarkably frequent, occurring in the very surface as well as at deeper levels at all stations in the Dardanelles, the Marmora, the Bosphorus and the Black Sea. In the Dardanelles it was very scarce at the surface, in the Marmora, however, remarkably numerous at and near the surface, especially in the eastern part of the sea. In the Bosphorus it was likewise very numerous at the surface, and in the (western region of the) Black Sea still rather copious at the surface at st. 172. The figures 33 and 34 show that the species has been able to develope special forms, adapted for this region. Schröder (1911 p. 36) has figured a somewhat similar form (var. *gracilis*) which was frequent in the brackish region of Sebenico on the Dalmatian Coast.

On the return through the Western Mediterranean *Dinophysis caudata* was present almost everywhere, but only here and there in greater numbers, sometimes abundant, though also occasionally only occurring singly, as far as the south coast of Spain, where it suddenly appeared abundant as far to the west as Gibraltar, and at st. 226 (Malaga) occurred in huge numbers, making by far the predominating plankton species. Outside the Straits it again became suddenly scarce, only somewhat more numerous at Lisbon.

The main species seemed to be more frequent in winter, though also occurring in summer, both in the Eastern and the Western Mediterranean, as well as in the Bay of Cadiz.

The *var. abbreviata* was very common in summer, especially in the region of the Atlantic Current proper and in the Bay of Cadiz. Extreme forms, like the *f. ventricosa*, were generally very scarce, only more frequent in the innermost, less saline, region.

Dinophysis caudata is obviously a euryhaline, but rather stenothermous, and decidedly thermophilous, species, otherwise widely distributed in the warmer regions of all three main oceans. At the Azores it is present all the year (Cleve 1901 a) and it follows the Gulf Stream far north-wards. Single specimens have been met with as far north as off the south coast of Iceland (July 1903, Paulsen 1904 p. 29) and off Bodö in Norway (Helligvær, January 1899, see Jörgensen 1905).

Fission stages and pairs of cells were not rare, especially in summer, when sometimes pairs of cells were much more frequent than solitary ones.

Dinophysis caudata is therefore undoubtedly indigeneous in the Mediterranean, occurring throughout this sea in winter as well as in summer, at the latter season frequent right into the Black Sea. It was in 57 summer samples the most frequent of the Mediterranean *Dinophysiaceae*. During the winter it decreases greatly in numbers, but increases again in summer, swelling up here and there to huge numbers. An immigration from the Atlantic seems to go on all the year, in autumn apparently followed by a most marked increase in numbers in the Alboran Sea.

12. DINOPHYSIS Kofoidii n. sp. ad int. (Fig. 35 p. 26).

D. diegensis var. caudata Pavillard 1916 p. 57, pl. III fig. 2. D. diegensis Kofoid (p. p.) 1907 b p. 313, pl. XXXIII figs. 61 and 58 (the latter f. curvata n. f. Kof.), not figs. 57, 59, 60).

Kofoid's species *D. diegensis* seems (to me) to be a rather doubtful one. His various figures are so different from each other both in size and appearance that the organisms in question in my opinion rather make the impression of a series of variations than of a definite species.

His figures 57, 59, 60 seem, however, to belong to a larger species, of about the same size as *Dinophysis caudata*, but differing from it in the evenly tapering body and apparently also in the shape of the longitudinal fin and perhaps the less coarse structure of the theca, while his figures 58, 61 look like a degenerate little form of *Dinophysis caudata*, but differ essentially from the f. *ventricosa* of this

species, which in my opinion obviously is such a degenerate form of *Dinophysis caudata var. abbreviata.* At least provisionally this smaller form may be considered a separate species, including the *Dinophysis diegensis* var. *caudata* Pavillard (l. c.), found by him in the Golfe du Lion in November 1914, and including Stein's fig. 8, which by Kofoid was referred to *Dinophysis diegensis.* This little species I have only with certainty observed in a sample from the Formosa Straits (off Futschou July 1903, kindly lent me by Ostenfeld), in a form, answering to Kofoids fig. 61, but with a regular process as in Pavillard's figure quoted (directed a little ventrally, Pavillard's figure seems to be a somewhat oblique side view).

In the collections of the "Thor" I have seen a similar form singly at st. 60 (just east of the Straits of Gibraltar in February, see fig. 35). This form is very probably only a degenerate form of *Dinophysis caudata,* probably of the main species, which in some cases shows a slight modification of shape reminding one of the form in question (see f. i. Stein's fig. 5 (1883, pl. XXI) and Schröder's "typical form" (1911 p. 36 fig. 7 b), both from the Adriatic). At Malaga Roads (st. 226, September) a form intermediate between this *f. subdiegensis* and the *f. ventricosa* was seen. (See also fig. 37).

If there is not a mistake in the stated magnification of the figures 57, 59, 60 with Kofoid (1020 (1250?) in stead of 638) this larger form must (apparently) be specifically different from the smaller (figs. 58, 61), which is *Dinophysis diegensis* var. *caudata* Pavill. Provisionally I should propose to retain the name *D. diegensis* for this larger form, and to designate the smaller as *D. Kofoidii* n. sp. ad int. As a typical form of this latter species I should consider Pavillard's figure, only with the slight modification above suggested (process not exactly axial, but somewhat ventrally directed). The characteristic features of this new species are the narrow process not set off from the "body", only about one third of the length of the cell body, the narrow longitudinal fin with three almost straight ribs (spines) of about equal length and somewhat diverging, the indistinctly striated "funnel" and a characteristic pale appearance, due to its finer structure. Otherwise it reminds one of *Dinophysis caudata.*

My *f. subdiegensis* would answer to Kofoid's figures 57, 69, 60, if the dimensions with Kofoid are wrong (in the way above suggested). In that case all the mentioned forms are comprehended in *D. diegensis,* which, however, so defined, can scarcely be kept separate from certain forms of *D. caudata* f. *ventricosa.* My new specific name might be of some use by drawing attention to this interesting form which in my opinion is a parallel to *Ceratium Ehrenbergii* Kof., the heteromorphous Baltic forms of *C. tripos* (similar to *C. furca*), and other forms.

Finally I shall only mention that Kofoid's fig. 58 is his first figure of the smaller species, but is justly designated as a special form, *f. curvata,* on account of its flexuose "tail". We should therefore avoid considering this accidental form the type of a possible new species.

Dinophysis diegensis was by Kofoid found rare in neritic plankton off San Diego (California).

Since the foregoing was written, I have seen a further form which may answer to *D. diegensis.* I have, however, only seen an imperfectly developed specimen with very thin-walled theca and almost invisible structure, but with well-developed upper girdle list and here with distinct radial ribs (fig. 36). It resembled a (left) half after fission, still with the other half very pale and indistinctly developed. From this I think we can provisionally take it that the relation between the dissimilar figures of *D. diegensis* given by Kofoid, and his strangely varying dimensions (length 60—110 μ) is in all essentials as above indicated, that we have here a series of degenerate forms of *D. caudata,* but that we may for the present assume that there is a smaller form, without distinct radial ribs in the upper girdle list, with more or less or not at all off-set lower prolongation, and a somewhat larger form, especially broader, with obovate cell-body, pointed below, and no developed prolongation, with distinct radial ribs in the girdle list and (possibly) differently developed left longitudinal fin (the lower part narrowing and longly decurrent). This last species can for the present be maintained as *D. diegensis,* as it answers to Kofoid's first figure, 57, while the one noted above as *D. Kofoidi* should most properly be called *D. caudata var. subdiegensis,* both as regards Pavillard's and my own form (fig. 35).

I still consider it likely, however, that KOFOID's figures 57, 59 and 60 were drawn from a different degree of magnification than stated, probably 1020 (instead of 628) as fig. 56 on the same plate, or abt. 1200.

From the coast of Arabia I have seen forms near to *var. ventricosa* which after fission showed a remarkably reduced antapical prolongation of the theca of the young cell (see fig. 37). These forms, both the young and the old, are strikingly different from the *Dinophysis caudata var. pedunculata* Schmidt, here found in the open sea, and from which they are most probably derived. In this case, we should, in my opinion, have a similarly accelerated sequence of fissions to those which apparently give rise to the links of LOHMANN's heteromorphous chains of *Ceratium tripos* from Kiel, APSTEIN's gemmation in *Ceratium tripos* and the tiny forms of *Gymnodinium pseudonoctiluca* in cultures, discovered by POUCHET (see JØRGENSEN 1911, pp. 37—39, 103—104).

13. DINOPHYSIS TRIPOS Gourret (Figs. 38—39 p. 30).

Gourret 1883 (pl. 3. fig. 53). D. homunculus Stein 1883 p. p. (pl. XXI figs. 3, 4, not 1, 2, 5). D. homunculus var. tripos (Gourr.) Lemmermann 1900.

This easily recognizable and very constant species was already detected by GOURRET at Marseilles (singly). STEIN (1883) did not separate it from the preceding species, but figured it as a variety without a special denomination. ENTZ (1902 a. 1905) mentions it as *Din. homunculus var. tripos* from the Quarnerolo in May, obviously much rarer there than the preceding species, which occurred there almost all the year. PAVILLARD (1905) reports if from the Étang du Thau as very rare there in November. SCHRÖDER (1906) found it very scarce in the "Ionian Sea" in March 1902. ZACHARIAS (1906) mentions it as answering to STEIN's fig. 3 under the name of *D. homunculus var. appendiculata*, from Palermo in July 1905. PAVILLARD (1909 a. 1916) reports it from the Golfe du Lion, where it is perennial and sometimes abundant. SCHRÖDER (1911) found it off Lucietta (Dalmatian Coast) in July 1909, rare.

On the winter cruise of the "Thor" it was met with at most of the stations (23 among 37 in the Mediterranean), but only in small numbers and often but singly. In the Western Alboran Sea it was wanting, and also in the Cadiz Bay, except at the shallow st. 64 (singly). The distribution indicates a feeble immigration in January and February and probably a stronger one in late autumn. In December of the same year I have seen it in samples from the region of the Straits of Gibraltar, where it was continuously present in a series of four samples from Cadiz to the south-east coast of Spain.

In summer it was much more frequent and numerous. On the route outwards in June it was already met with in the northern region of the Bay of Biscay, where it was abundant at st. 79 south-west of Brittany, but only present singly at st. 80. Thence it was wanting all the way to sts. 116 and 118 in the middle of the Balearic, where it again appeared singly. From st. 123 in the Ligurian Sea and st. 126 in the northern region of the Tyrrhenian it occurred at almost all stations to some distance before the Dardanelles (st. 167), and back again (from st. 180) to the station 216 south-west of the Baleares, very varying in numbers, swelling suddenly up at intervals from scarce to abundant (sts. 129, 0—600 m., 138, 190, 194, 196, 199, 200, 208). Like *D. caudata* it was generally scarcer at deeper levels, exceptionally, however, more numerous there than in the surface (sts. 129, 0—600 m., and st. 160, 0—30 m.). Also on the return voyage it was entirely wanting in the region of the Atlantic Current proper, in the Cadiz Bay and off the Coast of Portugal, but reappeared near Brittany (st. 246 and at Brest), now — in September — however only singly there.

Fission stages were observed in winter at st. 46 (off the African Coast), where it occurred somewhat more numerous, and in summer at sts. 79 (near Brittany), 129 and 131 (Tyrrhenian Sea), at the latter station only as a pair of cells after fission, everywhere in the morning, except at st. 46 (6^{35} p. m.).

The four Mediterranean stations, where it proved most abundant in the surface (sts. 138, 190, 194, 196) give as mean values of salinity and temperature 37.89 ‰ and 24.0°.

Outside the Mediterranean the species has been found in all three warmer main oceans, but is

generally much less frequent than *D. caudata*, especially in warmer regions, while it proves relatively frequent in the temperate border regions. In the Bay of Biscay it seems to be present and more or less abundant all the year, to the north as well as to the south, where it f. i. was very common in October 1909. In the English Channel it seems to be frequent to about midway in, and extends farther to the north, at least somewhat beyond a line from the north point of Scotland to the south point of Greenland (July 1889, Plankton-Expedition), to the west into the Irminger Sea. Exceptionally it is also met with on the west coast of Norway (off Bergen December 1901). Another area of frequency extends from the coasts

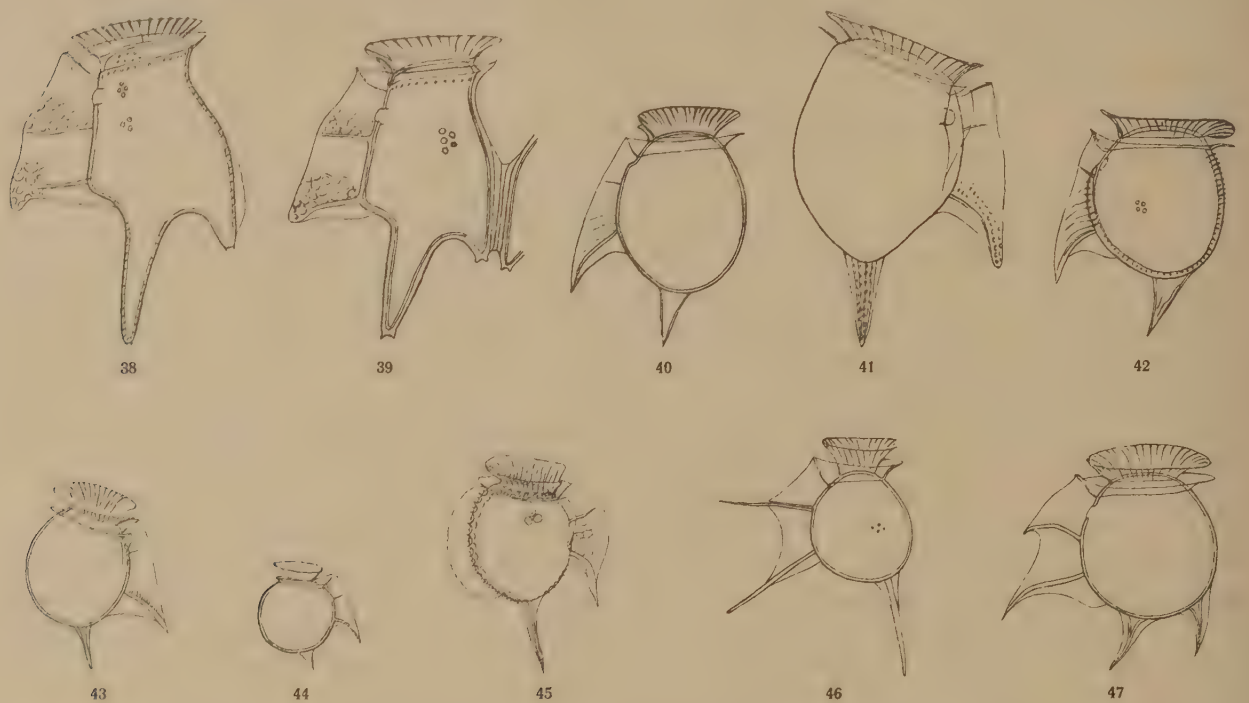


Fig. 38. *Dinophysis tripos* Gourr., $^{400}/_{1}$. St. 129. Fig. 39. *Dinophysis tripos* Gourr., *f. brevicauda*, after fission. $^{400}/_{1}$. St. 79. Fig. 40. *Dinophysis hastata* Stein, *f. uracanthides*, $^{400}/_{1}$. St. 187. Fig. 41. *Dinophysis hastata* Stein, *f. Phalacromides*. $^{400}/_{1}$. St. 156. Fig. 42. *Dinophysis uracantha* Stein, $^{400}/_{1}$. St. 231 (Cadiz Bay). Fig. 43. *Dinophysis uracantha* Stein, *var. mediterranea* n. var., $^{400}/_{1}$. St. 206. Fig. 44. *Dinophysis pusilla* n. sp., $^{400}/_{1}$. St. 206, 1945 m. wire. Fig. 45. *Dinophysis alata* n. sp., $^{400}/_{1}$. St. 187, 945 m. wire. Fig. 46. *Dinophysis Schütti* Murr. & Whitt., the smaller form, $^{400}/_{1}$. St. 152. Fig. 47. *Dinophysis triacantha* Kof., $^{400}/_{1}$. Deutsche Südpol-Expedition 18. IX. 1903 (Gulf of Guinea)

of South Africa along the west wind belt to Australia. In these extreme border regions of its occurrence it stands very well temperatures down to 13° and 12° C.

In the Mediterranean it proves, as mentioned, very constant in shape and size (see fig. 38), and answers very well to GOURRET's figure, which in this case is nearly perfect. In the form of the Bay of Biscay (see fig. 39) the larger process is a little shorter and broader, the end of the longitudinal fin less protracted and the structure of the theca perhaps a little coarser. It is the same form which GOUGH (1905 p. 333) figures from the Channel and which was found on the west coast of Norway. The area in the Southern Atlantic harbours another form, better answering to STEIN's fig. 4 from the "Südsee", which by LEMMERMANN (1900) was designated as *f. incurva*.

Like the preceeding species *Dinophysis tripos* also is a thermophilous species, but is stenohaline. It is undoubtedly indigenous or perennial in the Mediterranean and occurs throughout the Sea, in winter as well as in summer, in the latter season here and there swelling up in numbers to become by far the most numerous species, especially in the median regions of the sea. In winter it decreases seriously in

numbers and seems to vanish at many stations, perhaps especially in the Eastern Mediterranean. A successful immigration from the Atlantic seems to go on from late autumn to January and, to a lesser degree, to February; in summer, however, no immigration at all is to be traced.

Sectio V. HASTATAE Pavill.

Hypotheca in side view more or less asymmetrically oval or roundish, with one or two terminal spines below, belonging to the right half of the theca. Left longitudinal fin more or less acutely protracted below, and here with more or less powerful and long, often downward curving terminal spine. Structure of more or less small areoles.

14. DINOPHYSIS HASTATA Stein (Figs. 40—41 p. 30).

Stein 1883 pl. XIX, fig. 12. Phalacroma hastatum Pavillard 1909 p. 283, figs. A, B, (p. 282).

Cell in side view more or less irregular and asymmetrically oval, generally tapering a little toward the lower, rounded part, more flattened above. Upper girdle list directed obliquely upward to outward, with distinct, more or less close (numerous) radial ribs, of about same width as the cell or somewhat less. Terminal spine displaced toward the ventral side, and directed obliquely ventrally, rarely almost in the middle and pointing straight down, often with distinct median rib and more or less broad sail lists, or quite or nearly solid throughout, with narrow sail lists or none. Left longitudinal fin generally much broader below, and here more or less protracted into a point, supported by a long and powerfully developed spine, generally of equal length with the terminal spine, or often longer, more or less transversely cut off below and shortly decurrent. Lower half of longitudinal fin often with marked structure of ribs and imperfect reticulations; at times, the ribs in the upper girdle list also ramify into an indistinct and incomplete reticulation. Structure of fine areoles, indistinct to more powerfully developed, often with scattered "pores" which, however, rarely appear as distinct black spots, but are often visible as larger areoles. In our northern waters, the living cell is of a light rose, without cromatophores, or hyaline.

I have not been able with certainty to distinguish *Phalacroma hastatum* Pavill. from *Dinophysis hastata*, not even as a separate variety, though it is often rather characteristic. The species, however, varies at times to an extraordinary degree. In the northern waters, e. g. at Bergen, where it has been found in several places, albeit rarely — and in the Black Sea region, it is smaller, with narrower longitudinal fin, without the long curved lower spine, and with a small terminal spine, whereas in the middle part of the Mediterranean, and in warmer seas generally, it grows large, with powerfully developed spines. Very frequent is a pretty form which both in shape of cell and spine development points towards *D. uracantha*, with long and powerful, curved lower supporting spine in the longitudinal fin, and often powerfully developed, more centrally situate terminal spine, the upper girdle list not infrequently also higher and narrower. I tried for some time to distinguish this form as *var. uracanthides*, from a *var. Phalacromides*, answering to *Phalacroma hastatum* Pavill., but this again cannot, as far as my experience goes, be maintained with certainty.

Stein's first figure, 12, which should determine the type of the species, may, in my opinion, very well be my var. *Phalacromides*, the principal difference lying in the coarser structure of Stein's figure.

On the winter cruise of the "Thor", this species was very rare. I have only noted it from two stations at Naples, (sts. 23 and 26) and in addition, sts. 60, 62, 66, 68 and 69, in the Bay of Cadiz and just inside the Straits of Gibraltar. Here, at st. 66 (outside the Straits) it was fairly numerous, but otherwise very sparsely present everywhere. On the summer cruise it was found at 28 stations, everywhere very sparsely, from the Bay of Cadiz (st. 92 and at Cadiz itself) scattered throughout the whole of the Mediterranean right through to st. 172 in the Black Sea, in deeper water, but lacking in the Atlantic Current along the north coast of Africa. In the Tyrrhenian Sea it was frequent, but here and farther up in

the Mediterranean, often only present in deeper water. I have altogether seen it from the following stations (apart from the two mentioned outside the Straits): 126, 275 m. w., 128, 0—100 m., 129, 0—600 m., (Tyrrhenian Sea), 45 (Sidra Sea), 152 surface and 950 m. w. and 250 m. w., (southern Ionian Sea), 156, 250 m. w. and 950 m. w. and also at the surface, 158 (Levant), 161, 163, 0—80 m., (Ægean), 170, 0—20 m., 20—80 m., 85—200 m., 195—1000 m. (Marmora), 171, 172, 0—17 m., 17—50 m., several specimens, (Black Sea), 175, 350 m. w., 1150 m. w. (Marmora), 182, 545 m. w. (Ægean), 186, 245 m. w., 1145 m. w., 187, 0—25 m., 945 m. w., 190 (Ionian Sea), 194, 0 m., 1145 m. w., 195, 197, 198, 199, 200 (Tyrrhenian Sea), 204, 0 m., 985 m. w., 206, 1945 m. w. (Balearic Sea), 215 (Catalonian Sea), and 234, 95—200 m., 200—700 m. (s. w. coast of Portugal).

From this it would seem that the species must be considered as indigeneous in the Mediterranean, at any rate in the middle part, though it may appear to decline markedly in winter. Apparently, immigration from the Atlantic plays but a small part; according to the distribution at the stations there can at any rate be no question of any appreciable immigration in January, February, June, August or September, certainly not at the surface. Probably however, some individuals do come in at times from the Atlantic, also, the species seems to propagate. Fission stages were found, albeit seldom.

Recorded from the Mediterranean already by Entz 1902 (northern Adriatic). According to Pavillard (1916) the species is rare in the Golfe du Lion, and occurs there especially in summer; of "*Phalacroma hastatum*" he says that some few individuals may be found there at all seasons of the year. After Pavillard 1909, the species is noted by others from the Mediterranean only as *Phalacroma hastatum* (Schröder, 1911, Schiller 1912). Outside the Mediterranean, it has a scattered occurrence over a large area in the Atlantic, both north and south of the equator, but seems to be rare or lacking in the Florida Current and at the Azores.

15. DINOPHYSIS URACANTHA Stein (Figs. 42—43 p. 30).

? Stein 1883 pl. XX, fig. 22.

Cell in side view more or less asymmetrically roundish oval. Upper girdle list well developed, fairly high, at base abt. 0.6 maximal breadth of cell, marked funnel-shape, expanding upward, with distinct radial ribs. Left longitudinal fin very large, decurrent almost to end of the hypotheca; the lower part twice as broad as the upper, and prolonged into a long, downward curving, acute tongue supported by a long and powerful correspondingly curved (3rd) spine. Terminal spine long and strongly developed, at base without or with narrow sail lists, often set nearer the dorsal side and curving somewhat toward the ventral, or medially set, or ventrally set and so directed. Structure of theca small areoles, on strong, thick-walled cells very distinct.

The Mediterranean form (*var. mediterranea* n. var., fig. 43) is smaller, with a more — and almost entirely regular — oval cell body, which is thinner-walled, with pale, often indistinct fine structure, less strongly developed terminal spine, funnel narrower at base (in dorso-ventral direction) and less powerful radial ribs in the "funnel".

It is not so easy to determine exactly what Stein's *Dinophysis uracantha* is, partly because he gives two figures more or less unlike each other, (22 and 23) and partly because *D. hastata*, in luxuriating forms, resembles Stein's figures. There is, however, a smaller species which in the Mediterranean seems to keep more or less constant, and answers fairly well to Stein's figure 22, for which reason I have here described it as *D. uracantha*. The difference as compared with *D. hastata* lies chiefly in its smaller size, higher and dorso-ventrally narrower-based funnel, longer and narrower terminal spine, and a stronger, claw-bent, long third supporting spine (in the longitudinal fin). Stein's second figure 23, looks to me as if it might be a form of my *D. hastata var. uracanthides*; it differs from *D. hastata* chiefly in having the hypotheca rounded and shorter, and the funnel higher.

The species is rare in the Mediterranean, and always present in very few specimens, or only singly.

On the winter cruise of the "Thor" I have only noted it from five stations: sts. 11 (Ionian Sea), 25, 26 and 29 (off Naples) and 68 (Bay of Cadiz). On the summer cruise, it was taken at altogether 16 stations: sts. 80 (Bay of Biscay), 87 (n. w. coast of Portugal), and otherwise at 14 stations, of which 12 in deep water samples — namely in the Tyrrhenian Sea (126, 275 m. w., 129, 0—1100 m. w., 194, 1145 m. w., 199, 80—200 m.), in the Ionian Sea (152, 250 m. w., 950 m. w., 186, 1145 m. w.), in the Bay of Ægina (183), in the Balearic Sea (206, 1945 m. w. and surface), in the Bay of Cadiz (231, 1145 m. w.) and off the s. w. coast of Portugal (234, 200—700 m.) — and only two (three) at the surface (212 and 213 in the Catalonian Sea, besides 206). There is thus no immigration from the Atlantic directly traceable, and the more delicate Mediterranean form, above noted, suggests that the species can exist for some time in the middle and inner Mediterranean — where it is presumably widely distributed in deeper water, far more so than the few above mentioned stations show—though it may be likely that it would disappear if it were not renewed by occasional immigration of single individuals.

The species was first recorded from the Mediterranean by Schröder, 1900 (from Naples, he does not mention the far more frequent form *D. hastata*, so that his note perhaps applies to the larger and similar *D. hastata var. uracanthides* in the foregoing) and later by Cleve 1903 (from the Alboran Sea) and Pavillard 1916 (once in the Golfe du Lion, October).

Outside the Mediterranean, I have seen it from the Gulf of Guinea, and the southern Atlantic, also, on one occasion, off the coast here at Bergen, (Oct. 1901, surface).

16. DINOPHYSIS PUSILLA, n. sp. ad. int. (Fig. 44 p. 30).

Resembles a very small form of the foregoing. Cell-body in side view circular or broad oval. In all essentials as the foregoing, but in side view the "funnel" (upper girdle list) is comparatively far narrower at the base, less than half maximal breadth of body, and the left longitudinal fin proportionately shorter. Length and breadth: 27 by 29 μ and 30 by 26 μ, dorso-ventral diameter of funnel base 9 μ. No (distinct) striation of funnel and no distinct structure observed at all.

St. 206, 1145 m. w. Such small forms are evidently not very rare, but they are of course but little caught even with the finest plankton net. May possibly be a small, degenerate form of the foregoing species.

17. DINOPHYSIS ALATA n. sp. (Fig. 45 p. 30).

Resembles *D. uracantha*, but differing in having the left longitudinal fin broader above, not much broadening below, but with a nearly geniculate, strong, and longly excurrent lower spine, and in having an altogether different, coarsely reticulate structure, which in younger specimens is pale and less conspicuous, whereas older ones have high, elevated mesh-walls, which on the side contour produce the appearance of the cell being armed with numerous short spikes. Furthermore, the older individuals exhibit a broad sail list without visible structure along the dorsal side of the hypotheca for nearly its whole length. Terminal spine long, with narrow sail lists at base, funnel high, with distinct radial ribs. Length and breadth of cell in side view 45 by 38 μ, dorso-ventral diameter of epitheca (basal breadth of funnel in side view) half the maximal breadth of the cell, dorsal list $^1/_4$ to nearly $^1/_2$ breadth of cell, terminal spine more than $^1/_3$ length of cell.

A very remarkable species. Perhaps the highly peculiar *Dinophysis Rudgei* Murr. & Whitting is a species with similar structure.

I found it only in samples from the summer cruise of the "Thor": sts. 152, 250 m. w. and 950 m. w., 187, 945 m. w. (Ionian Sea), 199, 945 m. w. (Tyrrhenian Sea), 204, 945 m. w. and 206, 1945 m. w. (Balearic Sea), i. e. only in deep water samples, singly.

Sectio VI. SCOLOPS n. sect.

Besides the 3rd, also the 2nd (double) supporting spine in left longitudinal fin powerly developed with correspondingly projecting part of the list itself. Otherwise as previous section (Hastata).

18. DINOPHYSIS SCHUETTI Murr. & Whitt. (Fig. 46 p. 30).

Murray & Whitting 1899 p. 331, pl. 31, fig. 10. D. uracantha Schütt 1895 pl. 2, figs. 9 1-8, not Stein 1883.

A pretty and easily recognisable species, small, and not a little variable, but always easily distinguished by its three long diverging spines — two ventral in the left longitudinal fin and one antapical-dorsal terminal spine —, the asymmetrically roundish cell-form, and the high and narrow-based upper girdle list. It occurs in two forms, a larger, 54—62 μ long by 45—47 μ broad, often with downward curving ventral spines, and a smaller, 40—43 μ by 32—36, generally with straight ventral spines. Terminal spine often curved, in which case it and the lower ventral spine are often curved in opposite directions, so that the points turn down almost parallel (as in *D. uracantha*). Structure, "pores" and "poroids" (small areoles with regularly scattered larger ones).

In the winter cruise of the "Thor" it was taken at st. 11 (Ionian Sea) and at three stations in the Tyrrhenian Sea (sts. 26, 28 and 31) as also off the northern point of Corsica; otherwise it was only observed in samples from the Bay of Cadiz and just inside the Straits, (sts. 60, 66, 68 and 69). In the summer cruise, it was only observed in a single surface sample (st. 158, Levant) but otherwise in several deep water samples (14 stations out of 22) right in to the Marmora: sts. 234, 95—200 m., (coast of Portugal), 223, 1950 m. w. (Alboran Sea), 126, 100—200 m., 275 m. w., 199, 80—200 m. (Tyrrhenian Sea), 134, 75—125 m., 204, 945 m. w., 206, 1945 m. w., (Balearic Sea), 152, 250 m. w., (several specimens), 950 m. w., 186, 245 m. w., 1145 m. w., 187, 100—190 m., 945 m. w., 189, 945 m. w., (Ionian Sea), 156, 250 m. w., 950 m. w. (Levant), 163, 0—80 m., 182, 545 m. w., (Ægean), 170, 0—20 m., (Marmora).

The occurrence in deep water at st. 223, where also a fissioned cell with protoplasm was observed, suggests emigration from the Mediterranean; of an immigration from the Atlantic there is only a feeble direct trace in winter. This, together with the frequent occurrence in deep water samples, suggests that the species is indigenous in the Mediterranean in deeper water, apparently about 100 m. (?) below the surface.

It was first recorded from the Mediterranean by Pavillard 1896, (Golfe du Lion, once, Novr. 1913). Outside the Mediterranean it occurs in the tropical and subtropical Atlantic, especially south of the equator. Ostenfeld, (1900) notes it from 59°47′ N, 25°53′ W (abt. midway between the northern point of Scotland and the southern point of Greenland), at 7.4° C, but this is perhaps due to confusion with some other form (*Dinophysis uracantha?*).

19. DINOPHYSIS TRIACANTHA Kofoid (Fig. 47 p. 30).

Does not resemble any of the other species; most nearly related to the foregoing, with which it has in common a strongly developed medial spine in the left longitudinal fin, and correspondingly protracted point of the sail itself, so that this has two points, a smaller one in the middle and a larger one below, separated by an outwardly concave contour of the sail. Cell-body in side view broad ovate-oval to almost circular. Girdle lists broad, the upper medium high (or broad) with very distinct radial ribs. Breadth of epitheca (side view) more than half that of the cell. Left longitudinal fin broad and long, broadest below and longly and acutely protracted along the lower, strongly developed downward curving supporting spine. Two terminal spines, one dorsally and one nearer the ventral side, both curving toward the ventral side, and with more or less broad sail lists, either both free, or joined by the sail lists, or the ventral alone connected with the lower part of the large (left) longitudinal fin. Structure more or less distinct, of small reticulations or areoles.

It was surprising to find this rare species in the Mediterranean. I saw it only in 6 samples from

the summer cruise, in deep water, sts. 129, 0—600 m., 132, 195—600 m., 199, 945 m. w. (Tyrrhenian Sea), 156, 950 m. w. (Levant), 223, 1950 m. w., (western Balearic Sea), and 234, 95—200 m. (coast of Portugal), everywhere only singly. Previously, it was only known from a locality in the Pacific and one in the Indian Ocean; I have also seen it from the German South-Pole Expedition, 3° S 16° W (Gulf of Guinea, 18/9 1903). In the Mediterranean it seems only to be found below 200 m.

ORNITHOCERCUS Stein.

1. ORNITHOCERCUS MAGNIFICUS Stein p. p., Schütt (Fig. 48 p. 36).

Stein 1883 pl. XXIII, figs. 1—2 ("young specimens"), Schütt 1900 p. 262 figs. 8—10 (p. 255). O. minor Jørg. mscr.

When Schütt very rightly subdivided Stein's species *O. magnificus* into several, he retained Stein's name for the form corresponding to his first figure. This was unfortunate, in as much as it was evidently the larger species, Stein's figs. 4 and 5, which Stein actually meant, since he has taken the smaller species, fig. 1, as a not yet fully developed specimen. Schütt's name, however, should perhaps now be used for this characteristic and frequent, smaller species. I have partly employed an old manuscript name, which is therefore noted above.

Very easily recognisable from the double-scalloped antapical list, the narrowness of the epitheca (in side view) and comparatively high cell, proportionately narrow left longitudinal fin and the small dimensions. Cell abt. 40 μ long and broad.

It was found on the winter cruise of the "Thor" at nearly all stations, for the most part sparsely. I have noted it from sts. 10, 11, Port Alice, 14, 16, 20 (fairly abundant) Taormina, Naples, 24—26 (several specimens), 27—33 (likewise), 36—42, 45, 46, 53, 55, 59, 60, 66—69. It was most frequent and most numerous in the Tyrrhenian Sea. On the summer cruise it proved to be generally distributed throughout the whole of the Mediterranean from the Bay of Cadiz to st. 180 in the northern Ægean, numerous at several places, and at times predominating among the Dinophysiaceae. It was found at nearly all stations, sometimes also in deeper water (sts. 126, only in the sample drawn with 275 m. w., 129 at all depths, most numerous at 0—1100 m. — few specimens), 134, 0 m. very numerous, 125—200 m. singly, 152, 0 m., 950 m. w., 156, 0 m., 250 m. w., 950 m. w., 160, 0 m., 0—30 m., 184, 0 m., 945 m. w., 186, 1145 m. w., 187, 0 m., 945 m. w., 189, 0 m., 945 m. w., 192, 0 m., 545 m. w., 194, 0 m., 1145 m. w., 199, 0 m., 0—30 m., 945 m. w., 206 surface, very common, sparsely in sample drawn with 1145 m. w., 209, 0 m., 945 m. w., 1945 m. w., 234, 200—700 m.). In the western part of the Mediterranean and outside the Straits, it was sparsely found (sts. 92, 231 in the Bay of Cadiz, not noted for the Alboran Sea and in the Atlantic Current off the north coast of Africa, only sparsely present at st. 218, but numerous off the coast of Tunis farther east). Also in summer it was most numerous in the Tyrrhenian Sea, and also in the south-eastern and middle parts of the Balearic Sea, especially at sts. 134 and 206. North of the Bay of Cadiz, only observed at st. 234 off the west coast of Portugal, 200—700 m., singly.

From this, then, the species is doubtless indigenous in the Mediterranean, and not essentially dependent on immigration from the Atlantic. In summer it propagates here and there to a marked degree; fission stages were observed at several places, (specially noted from sts. 134 and 136 off the coast of Tunis, and st. 194, north of the Straits of Messina).

Outside the Mediterranean, the species has a wide distribution in the Atlantic, from the southern point of Africa to the south coast of Brazil, and northward to 40° N, 74° W in the northern part of the Gulf Stream off the coast of North America. In the Florida Current it occurs frequently from the Mexican Gulf northwards.

2. ORNITHOCERCUS STEINI Schütt (Fig. 49).

Schütt 1900 p. 260, fig. 7., O. magnificus Stein 1883 pl. XXIII figs. 4—5, ("old" specimens).

This, then, is what STEIN really regarded as the fully developed *O. magnificus*. It is altogether different from the foregoing species being of much larger dimensions, and much coarser structure, with broader epitheca (in side view) and especially in the antapical sail list, which is obtuse-angled below, and bounded by two straight or slightly concave lines. Cell abt. 65 μ in diam., generally broader than long.

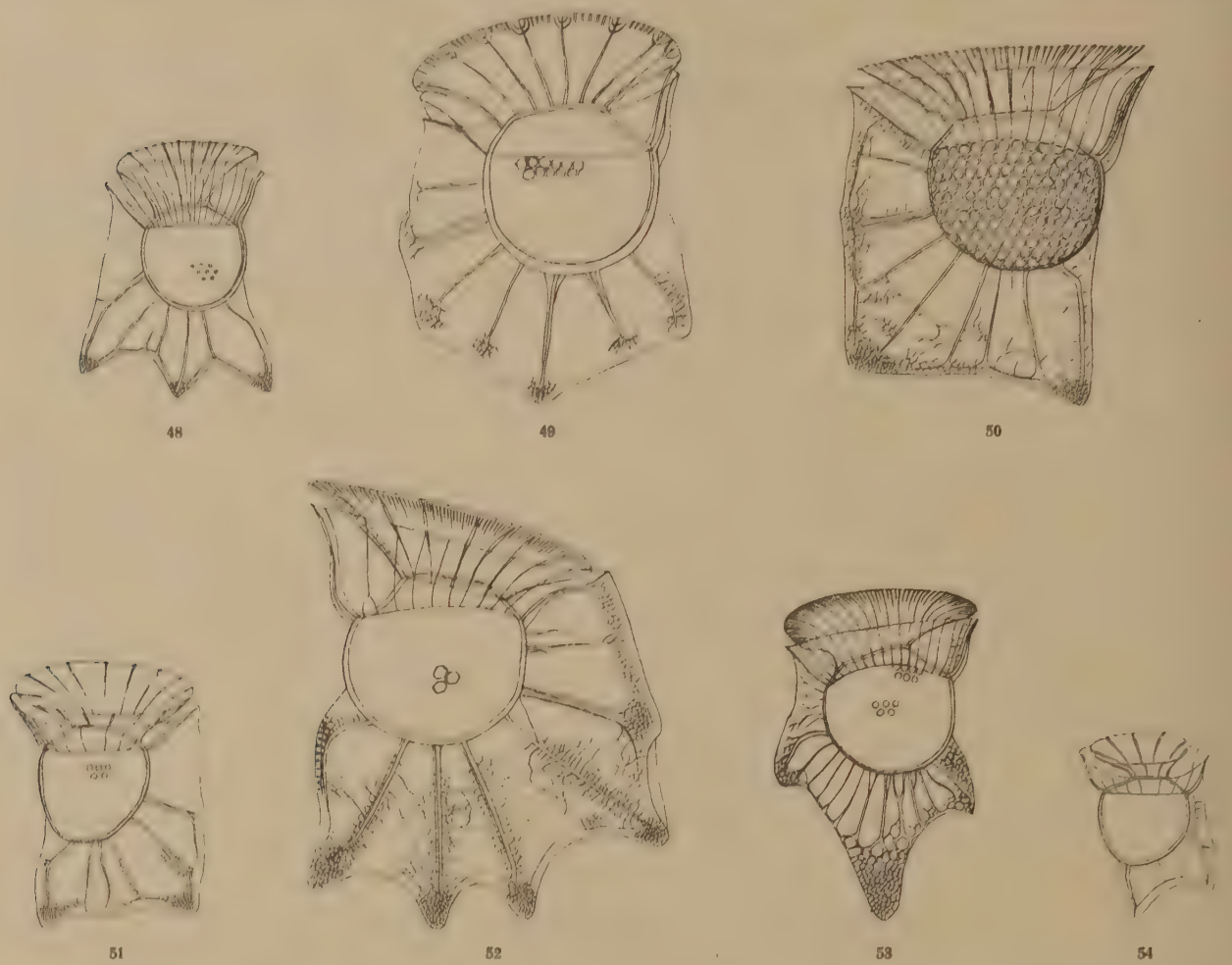


Fig. 48. *Ornithocercus magnificus* Stein, Schütt, $^{400}/_{1}$. St. 10. Fig. 49. *Ornithocercus Steini* Schütt, $^{400}/_{1}$. 1°46′ N 10°46′ W (Guinea Current) 11. VI. 1906, Chaves. Right half after fission; the left half still little developed. Fig. 50. *Ornithocercus quadratus* Schütt, $^{400}/_{1}$. St. 11. (The structure of epitheca and girdle is omitted in the figure). Fig. 51. *Ornithocercus assimilis* n. sp., $^{400}/_{1}$. St. 156. Fig. 52. *Ornithocercus serratus* Kof., $^{400}/_{1}$. St. 156. (Structure of theca only — as usual — suggested, otherwise the figure is complete). Fig. 53. *Ornithocercus Carolinae* Kof., $^{400}/_{1}$. St. 156. (As in fig. 52 only incomplete in regard to the structure of theca). Fig. 54. *Ornithocercus heteroporus* Kof., $^{400}/_{1}$. St. 11.

This large and handsome species has a similar distribution to that of the foregoing in the Atlantic, at any rate from 31° S. to 42° N. In the Florida Current it seems to be rare, at the Azores at any rate present in February. In the "Thor" material I have only seen it from sts. 66, 69 and 229 in the Bay of Cadiz (few specimens) and from st. 163, 0—80 m., (coast of Asia Minor) singly. It seems then only to occur accidentally in the Mediterranean, on occasions presumably having entered from the Atlantic. Like so many other tropical species it seems to thrive best in deeper water in the Eastern Mediterranean.

3. ORNITHOCERCUS QUADRATUS Schütt (Fig. 50 p. 36).

Schütt 1900, p. 254, figs. 1—4 (p. 256).

A large species, most like the foregoing, but very different in having the antapical sail cut off almost straight, which, together with the large and broad left longitudinal fin gives the organism in side view a squarish appearance (in the foregoing, pentagonal). Otherwise, in all essentials as the foregoing, also in dimensions. Third supporting spine in the antapical list, reckoned from the ventral side, longest, (in the foregoing, the fourth is the longest, or at any rate longer than the third). "Funnel" unusually broad at the top, with more ribs than in the foregoing.

On the winter cruise of the "Thor" it occurred at two stations in the Bay of Cadiz, (66 and 68) otherwise only in the Eastern Mediterranean, (sts. 11, 16, Naupaktos, 18, 20, Taormina) everywhere singly or very few. On the summer cruise it was found again in the Bay of Cadiz in June (st. 91) but otherwise now also only in the Eastern Mediterranean, and nearly always below the surface (sts. 152 and 156, 250 m. w., 950 m, w., 160, 30—100 m., 100—200 m., 161, a fragment at the surface, 163, 0—80 m., 167, 182, 545 m. w., 186, 245 m. w., 1145 m. w., 187, 100—190 m., 945 m. w., and 189, 945 m. w. Several specimens only at sts. 152, 250 m. w., an 163, 0—80 m., otherwise singly or very few. In the Western Mediterranean I saw it only at one place, st. 204, 945 m. w., an empty theca. On the return voyage it was found farther west only at st. 234 off the south-west coast of Portugal, singly at 200—700 m. depth. It is thus very rare in the Western Mediterranean, but probably frequent in the Eastern in deeper water, though probably always sparsely occurring. No signs of immigration from the Atlantic (but it may perhaps enter below the surface).

That it can occur in the Western Mediterranean is seen from Pouchet 1883, where it is shown as *Dinophysis galea n. sp.* from the Mediterranean coast of France, (or from Brest?). The name cannot be used for this species, (though possibly for *Ornithocercus Steini*) as the accompanying figures show *Ornithocercus Steini, O. quadratus, Phalacroma doryphorum* and *Ceratocorys horrida* (?). Schröder also, (1900) shows it, under the name of *Ornithocercus magnificus*, from the Western Mediterranean (Naples).

Outside the Mediterranean it has a similar distribution to that of the two foregoing species, but is rarer. It is rare in the Florida Current (off the coast of America, 33° and 36° N, Novr. 1909 and May 1910).

4. ORNITHOCERCUS ASSIMILIS n. sp. (Fig. 51 p. 36).

Very like a small form of the foregoing. Cell obliquely broad oval, generally somewhat longer than broad, much smaller than in the foregoing, and much narrower in proportion, abt. 43 μ long by 40 broad. Epitheca comparatively narrower in side view, (basal breadth of "funnel" smaller), little more than half max. breadth of the cell (in the foregoing abt. $^2/_3$ the breadth). Structure much less coarse than the foregoing. Otherwise with quadrilateral outline (in profile) as the foregoing, but more rectangular. It seems to occupy an intermediate position between the foregoing species and *O. heteroporus*, with which latter it has much in common.

I have seen this species (or form of the foregoing?) in one of the winter samples from the "Thor" (st. 11 in the Ionian Sea), and in four summer samples from the Eastern Mediterranean, generally from deeper water (sts. 152, 250 m. w., 950 m. w., 156, 250 m. w., 950 m. w., 163, 0—80 m., and 167). For a long time I regarded it as a smaller form of the foregoing species, and it is remarkable that it has only been found together with that. The constant and considerable difference, however, in shape of cell, structure, dimensions and to some extent also in basal breadth of funnel, rendered it natural to consider it as a distinct species.

Outside the Mediterranean I can up to now only give three localities for its occurrence, viz. 30°45′ S, 13°25′ W (the "Fram" $^5/_7$ 1911), in the Florida Current, 30$^1/_2$° N, 80° W, $^{30}/_{11}$ 1909 (s. s. "Texas") and near Ras Ekab on the south-east coast of Arabia (Handel-Mazzetti $^{28}/_{10}$ 1910).

5. ORNITHOCERCUS SERRATUS Kofoid (Fig. 52 p. 36).

Kofoid 1907, p. 206, pl. 15, fig. 93.

A large handsome species, in size, shape of cell, "funnel" and structure approximately as *O. Steini* and *O. quadratus*, but the antapical sail generally 3—4 scalloped with third supporting spine of same length as the fourth.

It was found in the "Thor" winter samples only at the two stations 66 (very sparsely) and 69 (several specimens), in the Bay of Cadiz. In the summer samples it was found again at one place in the Bay of Cadiz, (st. 92) and otherwise only in the Eastern Mediterranean and there in deep water samples at nearly all stations where such were taken (sts. 152, 950 m. w., 156, 250 m. w., 160, 0—30 m., 162, 163, 0—80 m., 167, 182, 545 m. w., 189, 945 m. w., everywhere singly save at st. 163, where specimens were somewhat more numerous).

The species seems thus to be not altogether rare in the Eastern Mediterranean in deeper water during summer; whether it is also to be found there in winter cannot be (certainly) determined from the "Thor" material. A fission stage was seen at st. 92 (Bay of Cadiz, June). It has probably come in from the Atlantic; whether it can continue to exist throughout the year in the Eastern Mediterranean is doubtful.

Outside the Mediterranean, it has been found, rarely, in the Florida Current, (30—32° N, coast of America, May 1910), far west of the Straits of Gibraltar (14° W, $^{29}/_{8}$ 1901) and in the Guinea Current $^{1}/_{10}$ 1903 (German South-Pole Exped.) and fairly common in the southern Atlantic between South Africa and South America 11° W to 38° W, 31° N to 17° N, June to August 1911 ("Fram").

6. ORNITHOCERCUS CAROLINAE Kofoid (Fig. 53 p. 36).

Kofoid 1907 p. 205, pl. 15, fig. 92.

Somewhat resembles *O. Steini*, especially in the pentagonal outline in side view, but is much smaller and with far more ribs in the antapical sail (the longest, or the two longest being the 8th or 7th from ventral side, the 4th is short) which has also a far more protracted end below. Cell about same height (length) as breadth, abt. 48—50 μ, structure coarse.

May perhaps be identical with *Histioneis Francescæ* Murr. & Whitting, which name in such case would take precedence.

This handsome and rare species I found in the "Thor" material from st. 20 (southern point of Italy, January), st. 66 (Bay of Cadiz, Feb.), st. 156, 250 m. w. (Levant, July) and st. 163, 0—80 m. (coast of Asia Minor, August) everywhere singly. Thus again a sub-tropical species which in summer seems only to occur in deeper water in the Eastern Mediterranean.

Outside the Mediterranean I have only seen it from the southern Atlantic, far east of the coast of Brazil, (20° 35′ S, 29° 30′ W, $^{12}/_{8}$ 1911 ("Fram"). Kofoid found it in the Pacific.

7. ORNITHOCERCUS HETEROPORUS Kofoid (Fig. 54 p. 36).

Kofoid 1907, p. 206, pl. 12, fig. 70.

A small species differing widely from all the foregoing by the far smaller (narrower) antapical sail which reaches but little, if at all, beyond the antapex of the cell, and here, at the dorsal side, is often most drawn out in a downward direction.

Kofoid's figure differs somewhat from the specimens I have seen, especially in structure, and also in the position of the lower supporting beam. The structure is (in well-developed specimens) according to my experience coarse, with large areoles, unlike in size, and I have hardly ever seen the lower supporting beam so far ventrally set as in Kofoid's figure. This is evidently drawn from a cell in slanting position. Length and breadth of cell about equal; 32—34 μ by 31—32.

It was surprising to find this dainty sub-tropical species so frequently in the Mediterranean. In

the "Thor" material from the winter cruise I found it at 17 out of the 37 stations in the Mediterranean, and 2 of the 5 in the Bay of Cadiz, but nearly everywhere singly or very sparsely. It was most frequent in the Tyrrhenian Sea, where it is noted from all stations but two (sts. 23 and 27); here, it was particularly frequent off Naples, at sts. 25 and 26 in somewhat greater numbers. At st. 33, close to the boundary between the Ligurian and the Tyrrhenian Sea, several specimens were also found; at the other stations, 10, 11, 14, 20, Taormina (Ionian Sea) and 42 (Balearic Sea) everywhere sparsely. On the summer cruise it was much rarer, again recorded from 17 stations, 9 in the Western Mediterranean and 8 in the Eastern: 120, 202, 204, at the surface, 206, 1945 m. w., 218 (Balearic Sea), 210, 213, (Catalonian Sea), 194, 0 m., 1145 m. w., Naples (Tyrrhenian Sea), 148 (Sidra Sea), 152, 0 m, 186, in salpæ, 187, 945 m. w., 192, 0 m., 545 m. w. (Ionian Sea), 156, 250 and 950 m. w., 158 (Levant), 161 (coast of Asia Minor), everywhere singly, only several specimens at the surface at st. 192.

Being small and light, the species is both difficult to take in the net, and easily overlooked or lost on examination, so that it is probably of more frequent occurrence than these records show.

It seems from this to be a true Mediterranean species, essentially independent of immigration from the Atlantic.

Outside the Mediterranean it has been found south-southeast of St. Helena and in the Guinea Current ($^{26}/_{8}$ and $^{1}/_{10}$ 1903, German South-Pole Expedition) as well as in the Pacific (Kofoid) and off the south-east coast of Arabia ($^{24}/_{10}$ 1910, Handel-Mazzetti).

HISTIONEIS Stein.

H. REMORA Stein (Fig. 55).

Stein 1883 pl. XXII, fig. 11. H. elongata Kofoid & Michener 1911 p. 295?

On the summer cruise of the "Thor", there was found at st. 152, 250 m. w., and st. 163, 0—80 m., a *Histioneis* species tolerably corresponding to Stein's figure of *H. remora*. Length (height) of cell 31 μ, breadth 38 μ. Stein's figure is doubtless at fault, for instance in the "collar" (lower girdle list).

The species is recorded by Pavillard 1916 from the Golfe du Lion (very rare, Aug. Oct. Decr.).

Fig. 55. *Histioneis remora* Stein, $^{400}/_{1}$. St. 152, 250 m. wire.

AMPHISOLENIA Stein.

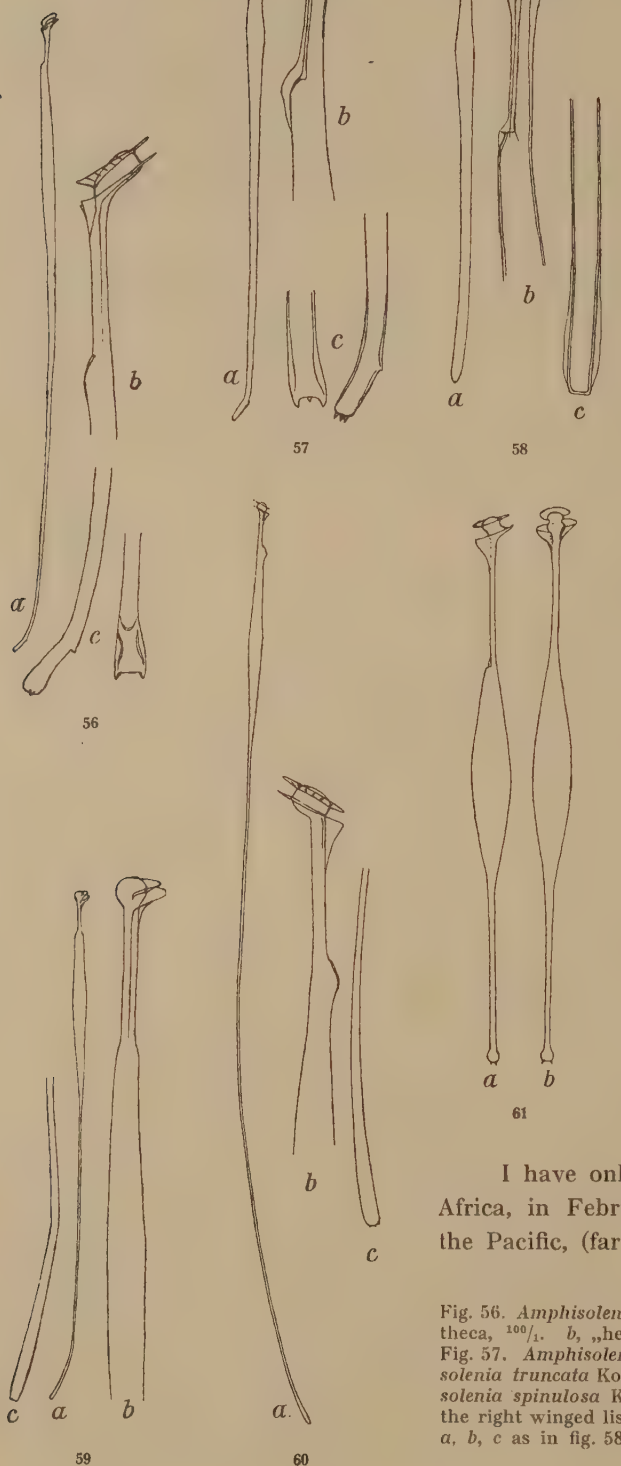
1. A. BIDENTATA Schröd. (Fig. 56 p. 40).

Schröder 1900 p. 20 pl. 1, figs. 16 a-c.

This, the most common of the *Amphisolenia* species, is known by the long and narrow cell in conjunction with the moderately broad, cross-cut and bidentate apex (in ventral or dorsal view).

On the winter cruise of the "Thor" it was found singly at by far most of the stations (27 out of 37 in the Mediterranean and two out of five in the Bay of Cadiz), from the Bay of Cadiz to the Bay of Ægina. Outside Naples it was somewhat more numerous than elsewhere. On the summer cruise it was rarer, and on the inward voyage it was not met with until st. 109, (the easternmost station in the Alboran Sea), and further present at sts. 111 (Balearic Sea), 148 (Sidra Sea), 152, 0 m., 250 m. w., (southern Ionian Sea), 160, 0—30 m., 161, 163, 167, 181, 182, 545 m. w. (Ægean), 187, 0—25 m., 945 m. w., 189, 945 m. w., 192 (Ionian Sea), 194, 199, 0—30 m. (Tyrrhenian Sea), 206, 1945 m. w. (Balearic Sea), 210, 215 (Catalonian Sea), 218, 219 (Balearic Sea, north coast of Africa) and 223 (Alboran Sea), again everywhere sparsely. Not seen after this.

It seems to immigrate from the Atlantic in the winter, and in summer to be rare, especially at the surface.



It was first recorded from the Mediterranean (Naples) by SCHRÖDER 1900. PAVILLARD (1916) finds it in the Golfe du Lion Novr. and Decr. very rare).

Outside the Mediterranean it has a wide distribution in the Atlantic, both the northern and the southern parts.

2. AMPHISOLENIA PALMATA Stein (Fig. 57).

Stein 1883 pl. XXI, figs. 11—15.

Much like the foregoing, and has been confused with it, but it has, apart from the two teeth in the dilated antapical end, also a smaller middle tooth. The cell seems as a rule also to be shorter and somewhat broader.

Specimens which, according to my opinion, belong to this species were found at sts. 11, 23, 45, 111, 192, 194, 204, 945 m. w. and 228, 1145 m. w.

PAVILLARD (1916) found it in the Golfe du Lion, very rare. Its Atlantic distribution cannot yet be stated, as it has been confused with and included under *A. bidentata*.

3. AMPHISOLENIA TRUNCATA Kof. et Mich. (?) (Fig. 58).

Kofoid & Michener 1911 p. 294.

Resembles a short and almost straight form of the foregoing, differs, however, from the two foregoing forms in the fact that the lower end of the cell lacks the characteristic foot-like form, with a small heel a little way up, found in the two former. In this species the antapex is not (distinctly) dilated, and is cut off transversely, without spines. Length 663 μ, max. breadth 24 μ, or 36 ‰ of the length. (In *A. bidentata* 22, in *A. palmata* 27 ‰).

My specimen differs slightly from the description quoted, particularly in the fact that the cell towards the lower end is slightly curved.

I have only seen it from st. 46 (Balearic Sea, off the coast of Africa, in February, one specimen). KOFOID's specimens are from the Pacific, (far to the north-east of Paumotu).

Fig. 56. *Amphisolenia bidentata* Schröd., Sevilla (6. XII. 1908, capt. Röd.). *a*, the whole theca, $^{100}/_{1}$. *b*, „head" and "neck", $^{400}/_{1}$. *c*, antapical end, in different views, $^{400}/_{1}$. Fig. 57. *Amphisolenia palmata* Stein, st. 111. *a, b, c* as in fig. 56. Fig. 58. *Amphisolenia truncata* Kof., st. 46. *a, b* as in fig. 56; *c* antapical end, $^{400}/_{1}$. Fig. 59. *Amphisolenia spinulosa* Kof., st. 192, 545 m. w. *a, b, c* as in fig. 58. Specimen after fission; the right winged lists still little developed. Fig. 60. *Amphisolenia extensa* Kof., st. 194. *a, b, c* as in fig. 58. Fig. 61. Amphisolenia globifera Stein. $^{400}/_{1}$. St. 192, 545 m. w.; *a* left side view, *b* ventral view.

4. AMPHISOLENIA SPINULOSA Kof. (Fig. 59 p. 40).

Kofoid 1907 b, p. 315, pl. 32, figs. 53—55.

Differs from all the foregoing in the fact that the lower half of the cell is extremely narrow, (often only 3 μ broad) so that the max. breadth of the cell is several times the breadth at $^1/_3$ from the lower end (in the three previous species it is abt. twice as great or less). Lacks "foot" and is slightly and evenly dilated below for a considerable length, and here rather sharply bent to the side. The lowest end itself has small indistinct spines. Abt. 720 μ long.

KOFOID's species should have three antapical spines similar to those of *A. palmata*.

I have only seen it (singly) from three of the "Thor" summer stations, 192, 545 m. w., 194 and 200 (near Straits of Messina and off Sardinia). KOFOID's specimens are from the Pacific (off San Diego).

5. AMPHISOLENIA EXTENSA Kofoid (Fig. 60 p. 40).

Kofoid 1907, p. 198, pl. 13, fig. 78.

Very like the foregoing, but unusually long and narrow, and towards the lower end evenly arched. Length 1292 μ, maximal breadth 17 μ, or 13 $^0/_{00}$ of the length, as in the foregoing several times the breadth at $^1/_3$ from the lower end. The latter with small processes, and slightly rounded off ("without spines", KOFOID).

I have seen it from st. 194 (south-eastern Tyrrhenian Sea, August); according to my notes, it also perhaps occurs at the two winter stations 25 and 26 (off Naples).

KOFOID's specimen was from the Pacific.

6. AMPHISOLENIA GLOBIFERA Stein (Fig. 61 p. 40).

Stein 1883 pl. XXI figs. 9—10. A. tenella Gran 1912 p. 935 fig. 8 b.

A dainty little species, altogether different from the four above noted, in the shape of the "head", position of maximal cell breadth, shape of the lower end, and size. The "head" is high and narrow, not so low and elongated as in the foregoing forms (least so in the lwo last species), the greatest breadth of the cell lies about the middle, not, as in the foregoing, more or less high above the middle; the lower end is swollen out to a globe shape, with two small spines, and the cell is (abt.) 200 μ long (or less) while all the foregoing are over 600 μ. The cell is also quite straight.

STEIN draws the antapical end as spherical, without spines. These are small and easily overlooked; also, the species seem to vary in this respect. GRAN's species (not described?) seems to be the same.

I have seen this species from four of the "Thor" samples; st. 68 (Bay of Cadiz, February, several specimens), st. 192, 545 m. w. (near Straits of Messina, August), sts. 199, 80—200 m., and 200 (east of Sardinia, August). STEIN's and GRAN's specimens were from the Atlantic.

TRIPOSOLENIA Kofoid.

Of this remarkable genus, three species occurred in the "Thor" material, only from the summer cruise.

1. T. BICORNIS Kof. (Fig. 62 p. 42).

Kofoid 1906 p. 105, pl. XV, figs. 1—2.

This is the most frequent species, with both posterior horns almost equally curved and turned slightly outward at the points, without spines at the ends. Distance between points of horns almost constantly 102 μ, the mid-body (32—)34 μ high by (38—)43—47 μ long, distance from upper end of the cell to lowest boundary line of the mid-body 80—85 μ.

It was found in the "Thor" material from the following localities: sts. 87, 234, 95—200 m. (south-west coast of Portugal, at the last-named, several specimens, otherwise, everywhere but singly) 126, 275 m. w., 129, 0—600 m., 0—1100 m., 132, 195—600 m., 194 (Tyrrhenian Sea), 134, 125—200 m., 185—350 m. (south-eastern Balearic), 152, 950 m. w., 187, 945 m. w., 189, 945 m. w., 194 (Ionian Sea), 182, 545 m. w., (Ægean), 209, 85—200 m., 1945 m. w. and 211 (Catalonian Sea).

It is thus found almost exclusively in deep water, between 120—200 m. in the Tyrrhenian Sea, at a similar depth in the Catalonian Sea, at st. 134 in the Balearic Sea both at this depth and between 185 and 350 m. As it was found at no less than 9 stations out of the 22 (in the Mediterranean) where deep water samples were taken, it is probably of wide distribution — albeit in small numbers — below the surface, especially, it would seem, between 100 and 200 m. As it was not found in the winter samples, we may suppose that it is not generally able to survive the winter at the surface; possibly it may also be found at that season deeper down, which cannot be seen from the "Thor" material.

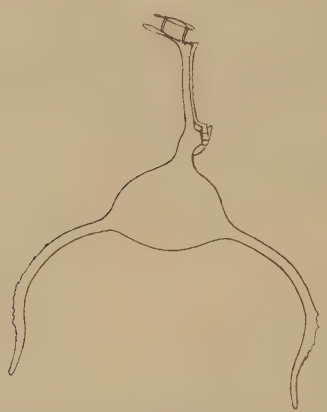


Fig. 62. *Triposolenia bicornis* Kof., $^{400}/_{1}$. St. 132.

Fig. 63. *Triposolenia ambulatrix* Kof., $^{400}/_{1}$. St. 175.

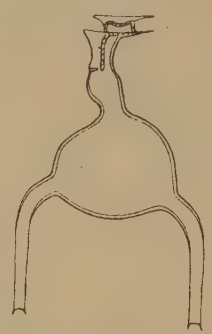


Fig. 64. *Triposolenia truncata* Kof., $^{400}/_{1}$. St. 126.

Outside the Mediterranean, it does not appear to have been recorded hitherto from the Atlantic save from the above mentioned "Thor" stations, (87, 234) off the coast of Portugal. Presumably, it occurs in the Atlantic also chiefly in deeper water. Kofoid found it off San Diego ("frequently in small numbers in vertical hauls from 135—30 fathoms to the surface, and rarely in surface catches").

2. TRIPOSOLENIA AMBULATRIX Kof. (Fig. 63).

Kofoid 1907 p. 203, pl. IV, fig. 24.

Much like the foregoing species, but differing in the lower mid-body (25 μ high) and especially in the unequally curved posterior horns, that in front curving more downward than the one behind. The points of these horns are, as in *T. bicornis*, tapering, and turned slightly outwards, the point of the front one most, and both have two tiny spines at the tip.

Differs somewhat from Kofoid's description and drawing, (his figure has "somewhat squarish shoulders" and the ventral posterior horn is pointed, without spines) but seems to be the same species. Distance between points of posterior horns 89 μ, mid-body 25 μ high and 38 broad, distance from apex to lower part of body 65 μ.

Closely related to *T. bicornis* and perhaps only a form of the same. Found only at st. 175, 350 m. w. in the Marmora, and probably also at st. 132, 195—600 m.

Kofoid found it in the Pacific, 9° S. 95° W.

3. TRIPOSOLENIA TRUNCATA Kof. (Fig. 64).

Kofoid 1906, p. 102, pl. 15, fig. 55.

Resembles the foregoing species, but is less slender, smaller but more robust, and is especially easily distinguished by the points of the antapicals, which are not rounded off, but apparently emarginate, not bent outward at the points (in side view) and here furnished with two small spines. Distance between points of the antapicals 62—81 μ, mid-body 34 μ high and 38—42 μ long; distance from apex to lowest (convex) boundary line of the mid-body 68 μ.

It was found at the following stations: 126, 120—500 m., 275 m. w. (east of Corsica), 170, 20—80 m., 175, 350 m. w. (Marmora), 182, 545 m. (near Euboea) and 206, 1945 m. w. (Balearic Sea), everywhere singly. It is thus only found in deeper water, at two places together with the foregoing species, in the Marmora in water (of high salinity) from the Ægean.

Only (?) previously known from San Diego ("plankton from 180—30 fathoms to the surface, but always sparingly").

III. BRIEF SURVEY OF THE OCCURRENCE OF THE SPECIES

As with the Ceratia, so also in the case of the Dinophysiaceae, the Mediterranean exhibits a remarkable wealth of species, the number of specimens, on the other hand, being as a rule no less strikingly small. Only a few species occur in the Mediterranean proper in any quantity, and then almost invariably at but very few localities. Only one species forms a distinct exception here, to wit, *Dinophysis caudata,* (*homunculus*) which in summer is abundant or numerous at many places, and covers a wide area. There are, however, a number of species which occur only singly, and at only a few of the 'Thor" stations.

With regard to the occurrence at different seasons, the cruises of the "Thor" present a comprehensive view of the state of things in summer, embracing the whole four months of June—September. The winter material is scantier by far, embracing only the period from mid-December to end February. It would have been of great importance here to have had samples from the western parts of the Mediterranean on the inward voyage, and a number of deep water samples.

The present material shows — again as in the case of the Ceratia — that there are but very few or hardly any species which can be called exclusively "winter-species", known only from the winter cruise, and all these are extremely rare (*Phalacroma favus,* sts. 10, 66, *Amphisolenia truncata* st. 46, and the doubtful species or degenerate forms *Dinophysis diegensis* and *Kofoidii* (= *D. caudata var. subdiegensis*)). On the other hand, there are no less than 14 species which were only found in summer, (*Phalacroma striatum,* (*elongatum*), *circumsutum* and *pugiunculus, Dinophysis alata, triacantha,* (*punctata* and *pusilla*), *Ornithocercus serratus, Histioneis remora* — which was, however, found by Pavillard in the Golfe du Lion also in December — *Amphisolenia spinulosa* and the three *Triposolenia* species).

This last group, exclusively summer species, forms a very interesting section, being — as indeed is also the case with the two "winter-species" — sub-tropical, and for the most part found only below the surface. This applies to no fewer than 9 of them (*Phalacroma elongatum, striatum, Ornithocercus serratus,* the *Dinophysis* species, and *Triposolenia ambulatrix* and *truncata*); there are also two (*Phalacroma circumsutum* and *Triposolenia bicornis*) each of which was only taken at the surface at a single station.

This remarkable fact, that sub-tropical (and tropical) species were found only, or almost exclusively, in deeper water with correspondingly lower temperature and sometimes only in the Eastern

Mediterranean, also applies to the Ceratia, and was further mentioned under that head (JÖRGENSEN 1920 pp. 105—108). The subtropical Dinophysiaceæ were in part also found only in the Western Mediterranean, or both there and in the Eastern.

As regards division into alien immigrants, the allogenous species, and native, indigenous species, the foregoing material in itself suffices to show that most of the species undoubtedly immigrate from the Atlantic, or at least that their stock in the Mediterranean is, during one or more of the months of February, June and September, augmented by immigration. It is for these three months that the "Thor" material permits of direct conclusions as to immigration, probably also, sts. 45, 46, may serve as evidence in regard to immigration (via the Straits of Gibraltar) during the month of January. See also JÖRGENSEN 1920 (p. 105).

Of the other species, for which no direct immigration can be noted, there are several which belong to these very sub-tropical species above mentioned. That they should really belong to the deeper and correspondingly colder places is hardly likely; in all probability, they will soon perish, though the less changeable conditions in deep water may give them a certain length of life. They are invariably found singly, or in very small numbers, and have thus presumably lost their power of reproduction.

Surer conclusions might be drawn from the lack of fission stages, or occurrence of the same, but as these are in any case the exception and not the rule, it is really only the presence of fission stages that can be used as material for conclusions, not the lack of them. Fission stages of *Dinophysis caudata* were found in quantities, and at many places, so that this species can doubtless be regarded as indigenous to the Mediterranean; here also, however, the material showed a distinct, and in winter marked, immigration through the Straits of Gibraltar. Apart from this, fission stages of the following were also found: *Phalacroma rotundatum, doryphorum, rapa* — only in the Bay of Cadiz, June — *Dinophysis acuta*, Bay of Cadiz, *D. intermedia, tripos, hastata, Schuetti, Ornithocercus magnificus* and *O. serratus* in the Bay of Cadiz. The most, however, we can conclude from these fission stages is that the species in question thrive or are "naturalised" in the water concerned; as regards the above-mentioned, *Phalacroma rotundatum* in the Balearic Sea, *Ph. doryphorum* likewise, *Dinophysis intermedia* in the Alboran Sea in June, *D. tripos* at sts. 46, 129, 131, *D. hastata* at st. 156 in the Levant, *D. Schütti* st. 223 in deep water, and *Ornithocercus magnificus* in the Middle Mediterranean.

True endemic species, exclusively Mediterranean forms, are doubtless rare among organisms which, like the Dinophysiaceæ and Ceratia, are chiefly surface forms. At present, there are some few species not known outside the Mediterranean, (*Phalacroma elongatum, stenopterygium, pugiunculus, Dinophysis pusilla, punctata, alata* and *Kofoidii* = *D. caudata var. subdiegensis*) but these are nearly all more or less exclusively deep water forms. On the other hand, these deep water organisms would surely be those among which we might chiefly expect to find endemic Mediterranean species, as they must be supposed to be most independent of the inflowing Atlantic water, which, of course, keeps mostly to the surface.

This inflowing Atlantic current will always be introducing new forms into the Mediterranean from without, so it is only natural that the Dinophysiaceæ and Ceratia of the Mediterranean should correspond in all essentials with those of the Atlantic. That they are not absolutely alike is due more particularly to the fact that not all species are able in the same degree to survive the comparatively abrupt transition to the Mediterranean. Hydrographical observations show that the inflowing Atlantic water is colder in summer and warmer in winter than the Mediterranean water, and this difference of temperature, together with the difference of salinity, seems to prove fatal to many species. The "Thor" material not infrequently shows that a species may be numerous in the Bay of Cadiz, but disappear immediately or very shortly in the Alboran Sea. The reverse case, of a species showing marked increase on entering the Mediterranean, also occurs, especially among the Ceratia; with the Dinophysiaceæ, it was rare, but was nevertheless noted, e. g. with *Phalacroma rapa* and *Dinophysis sphærica* in September, and *Dinophysis caudata* in June.

It would therefore seem likely that once or twice between summer and winter, conditions especially favourable to immigration exist; or at any rate, that the difference in temperature between Atlantic

and Mediterranean water in the neighbourhood of Gibraltar disappears. The distribution of species in the winter plankton also suggests that in late autumn (November?) there is a considerable immigration of such species as are either more frequent in the winter plankton than in the summer, or are found in summer for the most part in deep water samples (see JÖRGENSEN 1920 p. 105).

Immigration into the Mediterranean might also be supposed to take place from the Black Sea region, which, with its fresher water, has a plankton flora widely different from that of the Mediterranean, and consisting of but few species, some of which occur in very great numbers. The fresher water from this region can be traced at the surface far out into the Ægean, from its content of *Ceratium tripos* (see JÖRGENSEN 1920 p. 49). The only species of Dinophysiaceæ which showed any corresponding increase in this fresher water, however, were *Dinophysis caudata* — which occurred in two special forms, *f. Marmaræ* in the outer, and *f. pontica* in the inner regions, — and *D. acuta*. The question as to immigration from the Black Sea region therefore is, as far as the Dinophysiaceæ are concerned, reduced to the question, whether the *D. acuta* found in the Mediterranean can have immigrated from the eastward. The present material, however, offers no definite sign of such immigration; it is far more likely on the other hand, that the *D. acuta* found in great numbers in the Black Sea at st. 172, in deep water (below 50 m) found its way to that locality with the salter water from the inner part of the Mediterranean, and encountered more favourable conditions in the colder and less saline water. There are also distinct indications of immigration of *Dinophysis acuta* from the Atlantic to the Mediterranean.

The plankton of the Mediterranean naturally exhibits the character of a warm water plankton. The great majority of species are what I should call southerly-temperate; but there is also, as above mentioned, a considerable contingent of more sub-tropical character, which gives the plankton as a whole a more pronounced appearance of warm water plankton than would be expected from the latitude. For the causes of this, and the (presumably) greater immigration of sub-tropical species during the cold season, see JÖRGENSEN 1920 (p. 105—106).

Northern species, on the other hand, are almost or entirely lacking in the Mediterranean plankton. Sub-arctic or distinctly cold-water forms are altogether absent. The only species which can be called northern forms are *Phalacroma rotundatum*, *Dinophysis acuminata* and *D. acuta*. The first of these, however, is so much like certain warm water forms, e. g. *Phalacroma parvulum* and *Ph. operculoides*, and occurs in so many, as yet not properly distinguished forms that the statements in extant works as to its distribution are either so unreliable or so greatly at variance that for the present, it would be unwise to take the species as an indicator for cold water plankton generally. The same applies to *D. acuminata*, which in certain forms is closely allied to the warm-water form *D. ovum*, while others again lead over to the sub-arctic *D. granulata*. There remains then only *D. acuta*, which, though perhaps rather a cold than a warm-water form, must nevertheless be regarded as at any rate northerly-temperate. It occurs at many places in the Mediterranean, but is on the whole somewhat rare, and by no means numerous, and far more prevalent in deep water samples than at the surface. (Compare the remarks above (p. 21) about a supposed genetic connection between *D. acuta*, *D. intermedia* and *D. Schroederi*.)

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V. DIAGNOSES IN LATIN

OF NEW GENERIC AND SPECIFIC NAMES (ACCORDING TO THE RULES OF INTERNATIONAL BOTANICAL NOMENCLATURE).

Pseudophalacroma n. gen.

Sulca longitudinalis usque ad apicem continuata, fistula terminata. Ala longitudinalis sinistra angusta, spinis nullis vel inconspicuis instructa. Cetera ut in Phalacroma.

Paradinophysis n. sect.

Theca e latere visa rotundata, e facie ventrali elliptica, epitheca ± alte supra cingulum prominente, structura pro more subtiliter foveolata.

Euphalacroma n. sect.

Theca e facie ventrali et laterali cuneata, epitheca ± late convexa, structura ut in sectione praecedente, saepius tamen crassiore vel reticulum densum formante.

Cuneus n. sect.

Theca ut in sectione praecedente, saepissime tamen eximie cuneata structuraque crassa. Ala longitudinalis sinistra infra decurrens, non protracta nec spina excurrente instructa.

Argus n. sect.

A sectione praecedente affini praecipue differt structura crasse reticulata, theca minus evidenter cuneata, epitheca altius convexa.

Podophalacroma n. sect.

Hypotheca infra in processum crassum brevemque ± subito angustata. Cetera ut in sectione Euphalacroma, structura tamen saepius crasse reticulata.

Urophalacroma n. sect.

Theca spina antapicali solida instructa, partem dimidiam dextram hypothecae attinentem. Cetera ut in sectionibus Paradinophysi et Euphalacroma.

Phalacroma elongatum n. sp.

A Phalacroma acuto affini praecipue diversum magnitudine, epitheca minus alte convexa, hypotheca parum asymmetrica, infra magis protracta.

Dinophysis punctata n. sp.
A *D. lenticula* ala longitudinali sinistra longiore, epitheca minore atque structura subtiliore diversa.

Dinophysis pusilla n. sp.
A *D. uracantha* diversa minore magnitudine, hypotheca fere rotunda, ala longitudinali sinistra breviore.

Dinophysis alata n. sp.
Species egregia, uracanthae proxima, ala dorsali atque structura crasse reticulata subechinataque diversa.

Scolops n. sect.
Ala longitudinalis sinistra in medio acute protracta, spina secunda valida et excurrente spinae tertiae inferiori simili instructa.

Ornithocercus assimilis n. sp.
O. quadrato simillima, ab ea tamen diversus minore magnitudine, hypotheca e latere visa asymmetrica, comparate, ut et epitheca, angustiore.

REPORT

ON THE

DANISH OCEANOGRAPHICAL EXPEDITIONS 1908-1910

TO THE

MEDITERRANEAN AND ADJACENT SEAS

PUBLISHED AT THE COST OF THE CARLSBERG FUND

UNDER THE SUPERINTENDENCE OF

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MEMBER OF THE DANISH COMMITTEE FOR THE STUDY OF THE SEA.
LEADER OF THE EXPEDITIONS

VOL. III: MISCELLANEOUS PAPERS

COPENHAGEN
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REPORT ON THE DANISH OCEANOGRAPHICAL EXPEDITIONS 1908–10
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Vol. III. Miscellaneous Papers.

2.

The Sargasso Sea, its boundaries and vegetation.

By

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With 17 Figures and Charts.

Published April 30. 1923.

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1. Introduction.

Since Columbus, in the autumn of 1492, on his way to the Indies, made the first notes on the Sargasso Sea in the Atlantic Ocean, and up to the present time, many scientists have contributed to the elucidation of the peculiar conditions to which the Sargasso Sea owes its existence. In the majority of instances the Sargasso Sea itself was not the object of the journeyings and studies of these scientists. Yet special papers have been published on the matter in which the extent of the floating algae is discussed as well as their taxonomy, origin and biology as a whole. From time to time, too, the observations of many practical sea-men have added to our knowledge of the amount and occurrence of *Sargassum;* — on the whole much information about the Sargasso Sea has been obtained.

The fact that a unique material of collected Sargassum was put at my disposal has given me a sound basis for contributing much information about existing conditions. Furthermore the considerable discrepancies to be found in the opinions and publications of various scientists have led me to publish the results of my studies in the following paper. It was a matter of special interest to attempt to prove by this investigation the correctness of the claim urged by Krümmel in his well-known "Handbuch der Ozeanographie", that *Sargassum* is capable of being carried by a current from the Atlantic Ocean over towards the coasts of Europa and into the Mediterranean.

Systematic collections of the *Sargassum* in the Atlantic Ocean have never before been made on any great scale; therefore previous knowledge of the subject is based for the most part on scattered collections and observations made in the ocean, on study of algal-herbaria, on the present literature on the subject and on verbal reports of persons who have sailed across the Atlantic.

The material on which the present article is based comes from the collections made, at the instance of Dr. Johs. Schmidt, by the Danish Commission for the Study of the Sea, during the years 1911—1922. The material was brought to hand largely by the help of trading-vessels, including steam- and motor-ships and sailing vessels, whose crews have from time to time "taken stations" on their course. The vessels of the East Asiatic Co. have done a particularly large and excellent work. The *Sargassum* plants were not fished-up separately from the water, but were brought in with marine plankton by means of plankton-nets, which were drawn through the upper water-layers, usually for half an hour for each station. The value of such samples as an expression for the occurrence of *Sargassum* is by no means small. Sometimes such a quantity of *Sargassum* or other plankton is collected in the plankton-net, that it is impossible to take all the material; in such cases one or more characteristic samples of $^1/_2$—1 litre are selected and these give a very good picture of the greater or less abundance of *Sargassum* in the given locality. If single samples are perhaps but poor indicators of the abundance and appearance of *Sargassum* in the locality in question, yet when all the samples collected are taken into consideration we obtain a very fine picture of the occurrence of *Sargassum* in the Atlantic Ocean.

It goes without saying that all parts of the Sargasso Sea are not represented to the same extent. The material is most abundant from those domains most frequently crossed by Danish steamers, motor-ships or sailing-vessels in their routes across the Atlantic. The localities north and west of Bermuda are but incompletely represented in the collection, while the boundaries for the appearance of *Sargassum* in the east are very satisfactorily shown by the material.

Besides the plankton specimens thus collected, which come from about 500 localities in the Atlantic Ocean, other collections have been placed at my disposal, and I use this opportunity to express my thanks to those scientists who, both by furnishing me with material, and in various other ways have rendered me valuable assistance. P. JESPERSEN, M. Sc. has thus made collections on the scientific expedition of the motor-schooner, "Margrethe", in the Atlantic Ocean, July—December, 1913; while on board too, he has made many notes on the rate of occurrence of *Sargassum* in the various localities. Mr. JESPERSEN has attemped to answer several of my questions as to the biology and morphology of drift-algae, by his investigations made on the expedition. Unfortunately with the ship-wreck of the "Margrethe" off Anegada, one of the Lesser Antilles, most of the collections and notes were lost. Professor C. H. OSTENFELD, Ph. D., on a trip to the former Danish West Indies, collected material washed ashore and made observations on the biology and form-variations of the *Sargassum* in the ocean. Captain G. HANSEN has made notes on the relative frequency of *Sargassum* during a voyage across the Atlantic.

During the two Danish "Dana" cruises in the Atlantic, conducted by Dr. JOHS. SCHMIDT, the first, 1920—21, aboard m/s "Dana", the second, 1921—22, with the trawler "Dana" specially equipped for scientifical investigations, a great many samples were collected, mostly from a rowing boat, by means of a small hand net. The "stations" referring to said two "Dana" cruises have not been mapped down in my chart which, at the time, existed already in print.

Dr. HUGH M. SMITH, U. S. Fish Commissioner in Washington, D. C. has sent us samples of *Sargassum* from the eastern coast of North America. Professor W. G. FARLOW, Ph. D. of Harvard University, Cambridge, Mass., now deceased, has in letters given me valuable information on the *Sargassum* types found along the Atlantic coast of America; and Professor K. YENDO of Sapporo, Japan, who was kind enough to pay me a visit during his sojourn in Lund in 1913, made corrections in my determinations of the forms found in the material. Professor L. KOLDERUP ROSENVINGE, Ph. D. has on occasion rendered me assistance in investigating an *Ascophyllum*. My thanks are due to G. M. R. LEVINSEN, former inspector of the Zoological Museum in Copenhagen, now deceased, for his determination of Bryozoa on *Sargassum* and to P. KRAMP, M. Sc. for the determination of Hydroids.

At the same time as these collections and examinations of *Sargassum* were made, and also due to the initiative of Dr. JOHS. SCHMIDT through the Danish Committee for the Study of the Sea, experiments were made with drift-bottles in the Atlantic Ocean during the years 1912—1913. These were thrown overboard from vessels belonging to the United Steamship Co., and the East-Asiatic Co., and from m/s "Margrethe" on their cruises. Information about the conditions of currents in the Atlantic Ocean obtained on finding these bottles will also appear in this article.

2. Earlier Investigations.

In KRÜMMEL's valuable paper, "Die nordatlantische Sargassosee", (Petermann's Mitteilungen, Bd. 37, 1891), we find an historical survey of information on the Sargasso Sea, and I will therefore confine myself here to a brief outline.

As I have already stated, CHRISTOPHER COLUMBUS is the discoverer of the Sargasso Sea. On his westward cruise in 1492 he encountered great masses of loosely drifting algae at a point which is computed to be 28° N. Lat., 33° W. Long.[1] According to his notes, the algae were often closely united forming great cakes, yet this did not seem to have occasioned him any alarm. COLUMBUS had been to the Azores on former voyages, and in the vicinity of Cape Verde, which had probably familiarized him with similar masses of drifting algae. However, as we all know, his crew mutinied, one reason being that in these floating algae they thought to see a sign that dangerous submarine rocks or banks were near. COLUMBUS has noted many facts about *Sargassum* in his writings. He speaks of fresh and old plants with or without "fruit", that is to say bladders. On his cruise, too, he collected *Sargassum* and the crabs appearing on it. He concludes from the appearance of drift-algae in the ocean that there must be a huge submarine bank south-west of the Azores from which the algae have been detached. While COLUMBUS calls the algae "Yerba", OVIEDO[2] is the first to use the Portuguese word, Sargasso, (Salgazo) and BERNHARD VARENIUS[3] who seeks oceanographical information from Dutch mariners mentions the "famous sea, called by the Portuguese, 'mare de Sargasso'." We read here that the area stretches from 20°—34° N. Lat., the figures originate with JAN HUYGHEN VAN LINSCHOTEN[4].

In 1699, RUMPHIUS[5] mentions the plant under the name, "*Sargassum litoreum*" and expresses the opinion that it has been detached from the coast at some point or other. In LINNÉ's "Species Plantarum", (1753), however, it is called *Fucus natans*.

RENNELL, in his posthumous work on the Currents of the Atlantic Ocean, (1832), states that the Gulf Stream carries *Sargassum* with its waters from the Gulf of Mexico and the Straits of Bahama, but he does not deny the possibility that *Sargassum* can grow in the depths of the ocean.

Sargassum first becomes popular through ALEXANDER V. HUMBOLDT's descriptions in 1814, 1833 and others, (among which "Ansichten der Natur"). HUMBOLDT agrees with RENNELLS' theories and writes: "Es ist nach meiner eignen Erfahrung keineswegs zu leugnen, dass besonders an seinen Rändern fast in seiner ganzen Länge das Flussbett des Golfstroms, soweit ich es auf vier Seefahrten . . . . . in mehr als 5,600 Seemeilen Länge beschifft habe, mit zahllosen, der Richtung des Stroms parallelen Streifen von *Fucus natans* gefüllt ist. Aber es ist doch nicht leicht einzusehen, warum nicht ausserdem auch nahe Untiefen im Sargassomeer selbst zu jener Anhäufung mit betragen sollten. Der meisten Tang südwestlich von den Azoren sei frisch und in voller Vegetation als wäre er eben erst den Felsen entrissen . . . ."

HUMBOLDT is thus inclined to agree with COLUMBUS in believing in a large "Fucus-bank near Flores and Corvo", and he presumes the existence of a similar bank south-west of the Bermudas.

J. AGARDH[6] describes the location of the Sargasso Sea in the following: "COLUMBUS primus pratum hujus speciei vidit in itinere suo primo inter insulas Canarienses et Cabo Verde, ad altitudinem

[1] The computations were made by construction, by NAVARRETE: (Coleccion de los viajes etc., I, Madrid, 1858). KRÜMMEL states that according to the facta given in COLUMBUS' journal, the current must have carried him at least 1° further W. than the locality given above.

[2] Hist. general y natural de Indias, ed. F. de los Rios, Madrid 1851; lib. II, cap. 5 (Vol. I, pp. 23 ff.).

[3] Geogr. generalis. Amsterdam 1650, page 171.

[4] Itinerarium ofte Sshipvaert naer Oost ofte Portugaeis Indien. Amsterdam 1623. Chap. 95, page 142.

[5] Herb. Amb., VI.

[6] Species Algarum, 1848, p. 7.

viginti graduum, Hodie detegitur in occidentali plaga insularum Canariensium a 27°—38° latitudinis borealis, quod spatium occupat non per plagam continuam, sed instar insularum et pratorum. LAERIUS memorat se 15 continuis diebus per herbam aquae innatantem navigasse tam fortiter connexam, ut nisi securibus viam aperuissent, ibi navis remorata fuisset, et quidem in tam alto mari, ut projecto plumbo ad 500 ulnas nullus fundus detegeretur . . . ."

F. J. F. MEYEN, the botanist, (1834)[1] is the first to bring forward the theory that algae are constantly found drifting in the Sargasso Sea, and that they propagate vegetatively by partition. He finds that the drifting plants constantly lack organs of fructification, whereas these are always present in plants growing along coasts.

MEYEN's statements are very remarkable. He writes, (l. c. page 36): "Einige Seefahrer glauben, dass diese Tangen durch den Golf-Strom zusammengetrieben würden, und dass im Mexikanischen Meerbusen ungeheure Massen von Seekraut vorkommen, eine Meinung, die jedoch nicht mehr zu wiederlegen nötig ist, ..."; and on page 38: "Wir haben ungeheure Massen dieser Seepflanze gefischt, und alle die vielfachen Spielarten gefunden, die Herr AGARDH unter *Sargassum vulgare* beschrieben hat. Wir suchten aber vorzüglich nach der Wurzel dieser Pflanze, und um die Grundfrage entscheiden zu können, ob denn wirklich dieses Gewächs einst festgegessen habe, und etwa nur, zufällig losgerissen, auf der offnen See umherschwimme. Wohl Tausende und aber Tausende dieser Pflanzen haben wir besehen, und das Resultat dieser Nachforschungen ist, wir wagen es anzusprechen, dass diese Pflanzen niemals losgerissen sind, ja, sie haben niemals festgesessen. Schwimmend im Wasser haben sich ihre jungen Keime entwickelt, und Wurzeln und Blätter, aber beide von gleicher Beschaffenheit, nach allen Seiten ausgetrieben". (Page 39): "Nach unserer Meinung schwimmen sie an dem Orte ihres Vorkommens vielleicht schon seit Tausenden von Jahren, ihre Masse muss aber jährlich zunehmen, wenn auch diese Zunahme, wie leicht zu ersehen, schwer warzunehmen ist".

HARVEY, (1851)[2] is of the same opinion and he describes, how the plants grow and break up into smaller ones, so that even a little branch will continue to push out new branches and leaves.

In this matter also Captain LEPS, (1865)[3] agrees with MEYEN and HARVEY. He writes that he cannot believe that drifting *Sargassum*-plants come from the West Indies. He locates his "Mer de varech" between 28° and 79° W. Long. and 16° to 17° and 36° to 38° N. Lat.

MAURY, (1866)[4] inclines to RENNELL's theory on the origin of *Sargassum* in the Gulf of Mexico and adds that according to the direction of the ocean currents, it is only natural that floating material will accumulate in the almost currentless centre.

GEORG V. MARTENS[5] claims that drift-algae are able to grow while drifting, as MEYEN, THUNBERG and HARVEY have stated. At the same time he presumes the plants to be conducted from the Gulf of Mexico into the ocean, and he discusses the possibility of algae coming from the south-eastern coast of Africa, that is to say from the Indian Ocean, (Mozambique Channel), for he discovers Indian types of epiphytic organisms on the *Sargassum*. Even though the conditions of the currents in the Atlantic Ocean might permit such a theory, yet the fact that these types of *Sargassum* have not been found in those localities where they are supposed to have originated, makes this explanation of the origin of the Sargasso Sea but little satisfactory.

OTTO KUNTZE[6] denies the existence of HUMROLDT's "Fucus-Banke"; nor does he believe that *Sargassum* is able to grow any considerable time. Storms set algae adrift from the coasts of the West

[1] "Reise um die Erde in den Jahren 1830, 1831 und 1832", Theil I. Berlin, 1834.
[2] "Nereis Boreali-Americana", part I, 1851.
[3] Bull. Soc. de géographie, 5ième Série, IX, p. 292—309.
[4] Phys. geogr. of the Sea, p. 88. Explanations and Sailing directions, Vol. II.
[5] Die preuss. Exp. nach Ostasien, 1866.
[6] Engler's Jahrb., I, page 191, 1881.

Indies, and he considers 3 months the maximum longevity of such algae. KUNTZE denies too, the possible existence of a domain which might be called the Sargasso Sea.

E. PERRIER[1] writes, — without knowing KUNTZE's article, — on the basis of his observations from on board the "Talisman", August 1883, of "une immense prairie flottante", located between the Canary Islands, the Azores and the Bermudas. Like MEYEN and LEPS, he presumes *Sargassum* to live pelagically.

SCHÜTT, who took part in the German Plankton Expedition in 1889, observed that *Sargassum* grows a little while drifting.

KRÜMMEL (l. c. 1891) is of the opinion that the drifting *Sargassum* grows only very little. His observations will be quoted later on in this chapter.

HENTSCHEL (1921)[2], who has been studying the epiphytes on the drifting *Sargassum* gives some important arguments in favour of the theory that the plants live and grow constantly in drifting condition.

In summing up the above we see that divergent theories have existed on the biology and occurrence of *Sargassum* in the Atlantic Ocean.

The first, that *Sargassum* grows on banks in the depths of the sea near the Azores and the Bermudas may be left out of consideration. These banks do not exist. The ocean is 3,000 metres deep or more and it is impossible for any plant requiring light and assimilating carbonic acid to live here.

Two different theories on the biology of *Sargassum* remain.

According to the first the algae drifting about in the Atlantic Ocean are only particles of coastal algae that have been torn loose. During a short time, a few months at most, these are able to keep afloat. The supply is constantly being increased from the shore where storms in the West Indies and off the rocky coasts of the Bahamas detach great quantities of *Sargassum*. This is first carried in a circle north-east then south with the Gulf Stream and finally left in the central, almost currentless, section of the Atlantic where it at last sinks to the bottom of the ocean.

According to the second theory, *Sargassum* is able to keep afloat indefinitely and vegetate, — though not to fructify, — and thus the supply is kept constant. By the partition of a single individual many others may come into being; these in time grow to be just as large as the mother-plant.

There are, too, many theories on the occurrence of drift-*Sargassum*, that is to say on the boundaries of the Sargasso Sea.

The oldest theory that a Fucus-domain is to be found near the Azores and another further west, has no longer any supporters. As KRÜMMEL writes, (l. c. p. 136) this false idea is based on the following: "Die 'grosse Bank von Flores und Corvo' ist weiter nichts als die Summe aller aus den verschiedensten Zeiten herrührenden Beobachtungen von treibendem Kraut entlang der Segelroute der aus südhemisphärischen Gewässern nach Europa heimkehrenden Segelschiffe, die, wie der Seeman sagt, ihren 'Durchstecher durch den Passat' machen" . . . . . "Kurz, wo mehr Beobachter, da sind mehr Sargassovorkommen notiert . . . . ."

If we compare the descriptions found in literature of the boundaries of the Sargasso Sea, we find many discrepancies.

As I have stated JAN HUYGHEN VAN LINSCHOTEN (1623), locates it between 20° and 34° N. Lat. STEN BILLE[3] writes in his report on the cruise of the Danish corvette "Galathea", around the world, that he expected to find the Sargasso Sea lying between 33°—43° W. Long. and 18°—37° N. Lat., but his ship

[1] Les explorations sous-marines. Paris, 1886, p. 77.

[2] ERNST HENTSCHEL: Über den Bewuchs auf den treibenden Tangen der Sargassosee. — Beiheft z. Jahrbuch der Hamb. Wiss. Anst. XXXVIII, 1921.

[3] "Beretning om Corvetten Galathea's Rejse omkring Jorden i 1845—1847", Vol. I. Copenhagen, 1853.

encountered much *Sargassum* considerably further west. His expectation may probably be explained by the fact that even as late as 1911, the chart over the North Atlantic edited by the Royal Danish Hydrographic Office "Sökaart-Archiv" located the Sargasso Sea in a 10 degree section 30°—40° W. Long. and 20°—30° N. Lat., while on the point 58° W. Long., 25° N. Lat., "Søgræs" (sea-weed), only, was designated.

LEPS, (l. c.) gives as the boundary of that territory from 28°—79° W. Long. and 16° to 17° — 36° to 38° N. Lat.

G. v. MARTENS, (l. c.) locates the North Atlantic "Krautsee" at 39°—74° W. Long. and 19°—45° N. Lat.

KUNTZE, (l. c.) denies the existence of a definite tract which may correctly be called Sargasso Sea. He writes in this connection, (l. c. p. 199): ". . . . man kann oft tagelang das Sargasso-Meer durchfahren, ohne darin mehr zu sehen, als in der Nordsee, von wo man es (*Sargassum*) schon von EHRHART, mit gedruckter Etikette vertauscht, öfters in den Herbarien findet".

Captain HALTERMANN, (Deutsche Seewarte), sends KUNTZE a written account of his sea-faring experiences during thirty years, but is unable to alter KUNTZE's opinion. Among other matters HALTERMANN writes, (KUNTZE l. c. page 234): "In den Karten mancher deutscher Atlanten ist die Begrenzung der sogenannten Sargasso-See ganz falsch angegeben. Östlich von 35° W. Lg. von Greenw. trifft man höchstens Spuren von Sargassokraut an. Zwischen 20° und 35° N. Br. und zwischen 35° W. Lg. und Westindien und Ostrand des Golfstromes liegt das Gebiet des Sargassomeeres. Westlich von 40° W. Lg. und zwischen 25° und 32° N. Br. treibt es dichter; westlich von 45° W. Lg. und in etwa 30° N. Br. sieht man dichte Flächen von Sargassokraut, höchstens jedoch vielleicht 100 Fuss im Durchmesser haltend, ziemlich häufig treiben. In ihnen ist das Sargasso dicht zusammengedrängt, so dass in Folge dessen dort die Tangspitzen beständig aus dem Wasser hervorragen. Oft sieht man Krabben von der Grösse eines kleinen Apfels oben auf solchen Krautflächen stehen".

KRÜMMEL's[1] work, (1891), which contains an attempt at fixing the boundaries of the Sargasso Sea, is the first to be based on purposeful investigations of the occurrence of drift-algae in the Atlantic Ocean. The material used by KRÜMMEL has been procured through the "Deutsche Seewarte", which for many years has required sea-captains to make systematic notes on all the drift-algae observed. A large material has thus formed the basis for this author's investigations. KRÜMMEL has used the material in the following way.

The Atlantic Ocean was divided into sections of 1° each. The number of times *Sargassum* was recorded in the journals from each 1° section was counted. Knowing how many cruises had been made across each section, it was easy enough to find a figure to express the percentage of probability for encountering *Sargassum* in crossing the 1° section in question. KRÜMMEL lets r represent the number of cruises made in 1 section per month, and s the number of cruises on which *Sargassum* is observed. $p = \frac{s}{r}$ is the *Sargassum* frequency. To avoid working with such small units as 1° sections, KRÜMMEL combines the results for each 5° section (= 25 1° sections) and writes: "So wird für ein Fünfgradfeld für einen bestimmten Monat die mittlere Wahrscheinlichkeit, *Sargassum* zu treffen, oder die monatliche Sargassofrequenz $w = \frac{1}{25} \sum [p] \ . \ . \ ."$[2]

[1] "Die nordatlantische Sargassosee", Petermann's Mitteilungen, 1891, p. 129.

[2] This expression seems to me unfortunate. It would be more correct to add the frequencies for 1° sections and omit "$\frac{1}{25}$". The divider may easily give rise to misunderstandings. The expression KRÜMMEL uses for "w" is the average frequency, not for a 5° section, but for every 1° section in the 5° section and this is very different from "the probability, for encountering *Sargasssum* in a 5° section". When KRÜMMEL gives a maximum *Sargassum* frequency of 10.5 in a 5° section for the entire year, it means that ships sailing correspondingly often throughout the year through the given 5° section will on the average have encountered *Sargassum* in 10.5 % of the 25 sections on each cruise. The method and frequencies have other unavoidable sources of inaccuracy as well. It may of course be taken for granted that the probability for finding *Sargassum* in a given degree-section increases with the de-

The figures representing *Sargassum*-frequency thus obtained, were then noted by KRÜMMEL on a chart of the Atlantic Ocean, divided into degrees of latitude and longitude. In this way he obtained a comprehensive survey of the relative frequency of *Sargassum* in the various localities and at the various seasons of the year. Part of this great work is done by KRÜMMEL himself, part by his pupil, GUSTAV ANTZE[1], who follows the methods of his master.

Based on the figures thus charted, KRÜMMEL now draws some "Isophykodes", for the appearance rate of 0.3 %, 1 %, 5 %, and 10 % respectively. The latter includes an area covering an extent of 4,440,000 square kilometres. KRÜMMEL propose that in the future this area be designated on the map as the Sargasso Sea.

SCHOTT[2], however, maps out the 5 % isophykode embracing about 7,000,000 square kilometres of the ocean. The isophykodes are reproduced in Fig. 1.

KRÜMMEL believes that each year great quantities of floating *Sargassum* are washed adrift by the North Atlantic summer storms, particularly from the vicinity of the Antilles and the Bahamas; this *Sargassum* is carried by the Gulf Stream into the ocean. According to his theory *Sargassum* has the power of drifting about for a long time, not merely a couple of months, but, as it becomes overgrown and encysted with Bryozoa and other epizoa will finally sink to the bottom. The Sargasso-plant grows a little, but (l. c. page 140): "eine Vermehrung durch Sprossung erscheint jedoch ausgeschlossen: die Wachstumsbedingungen sind doch zu ungünstig".

In computing the frequency percentage for the various seasons of the year, spring, summer, autumn, and winter, KRÜMMEL notes the following conditions[3] (l. c. page 138): "Nördlich von 45° Breite wird treibendes Kraut eigentlich nur im Spätsommer und Herbst notiert, weiter im Osten auch wohl im Dezember noch; es fehlt durchaus im Frühling. Ebenso liegt in der zweiten Fünfgradzone das Maximum der Sargassohäufigkeit noch im Herbst- oder Winteranfang, doch sind auch die anderen Jahreszeiten nicht ganz frei von *Sargassum*. Je weiter nach Süden wir kommen, desto mehr wächst auch die Frequenz aller Quartale, nahe 30° Breite wird mehr der Winter das Maximum, und südlich 25° Breite wird es sogar der Frühling. Man kann daraus unmittelbar ablesen, wie das Sargasso im Sommer aus dem Golfstromgebiet nach Südosten wandert, dann auch weiter dem herschenden Meeresstrom folgend, im Winter 30° und im Frühling 25° Br. überschreitet. Die stete Zufuhr von neuem Sargasso aus dem Florida- bezw. Golfstrom kommt also deutlich in jenen Zahlen zum Ausdruck: einer Hochflutwelle ver-

creasing speed at which a vessel crosses the section in question, and the larger the part of the section sailed across. Any 1° section in the centre of the Sargasso Sea will probably always contain drifting *Sargassum* in greater or smaller quantities. It is also an open question whether or not sea-captains may on the average be called keen, diligent observers. The better observers they are, the higher the frequency-rate. The season of the year may perhaps be a factor to be considered in judging the value of the observations. Climate and light conditions may prevent the observers from being equally interested and the observations from being equally good in summer and winter. However all these critical remarks do not prevent appreciation of the very great value of KRÜMMEL's material. It renders a passable comparison between the various tracts of the Atlantic Ocean possible. Still it is very striking that the 5° sections in the Sargasso Sea lying between 35°—40° W. Long. (see Fig. 1) show an astonishingly high frequency-rate in comparison with those sections lying east or west of them. These high-rate sections are located just on the sailing route from the South Atlantic Ocean to the English Channel and there is indeed but small reason for KRÜMMEL to criticize the theories of ancient writers as to the existence of a "Fucus-bank" as he does (see the quotation, page 7). Still I do not doubt but that the high frequency-rate appearing, in this track, according to KRÜMMEL's method is only due to the fact that better observations have been made on this sailing-route; sailing-vessels move more slowly than steamers, and as they remain longer in each degree-section more positive observations will, eo ipso, be noted.

[1] "Revision der Oberflächenströmungen des nordatlantischen Ozeans auf Grund der Triftphänomene" (Inaugural-Diss., Minden i. W., 1901).

[2] "Geographie des atlantischen Ozeans", 1912.

[3] At the time that KRÜMMEL discussed this matter he had not yet computed the frequency rates for the domain east of 50° W. Long.; and the 10° section 40°—50° W. Long., 20°—30° N. Lat. was also wanting. The conclusions drawn by this author seem to have been reached too soon. As a matter of fact we find that the seasonal frequencies noted by ANTZE for the remainder of the Sargasso domain, agree but poorly with KRÜMMEL's theory.

Fig. 1. The Isophykodes of KRÜMMEL, showing *Sargassum* frequencies of respectively 10, 5, 1, and 0.3 percentage. In the 5° sections are printed the frequencies for the entire year. (See text!)

gleichbar, pflanzt sich das Maximum, vom langsamen Strom getragen, erst südlich, dann südwestlich fort".

I will refrain from discussing KRÜMMEL's account further at present; however let me say at once that my results do not in the main agree with KRÜMMEL's theory, as I will demonstrate later.

3. Physiognomy and Boundaries of the Sargasso Sea.

One who remembers the old accounts of encountering in certain parts of the North Atlantic Ocean such huge masses of sea-weed that the speed of the ship was reduced or the vessel brought to a standstill, will have obtained a very erroneous impression of the Sargasso Sea. Even in the very heart of the district the surface of the sea is open. The only positive characteristic of the Sargasso Sea is the con-

stant occurrence of drifting sea-weed belonging to the above-named genus of the *Fucaceae* family. Sometimes the plants drift separately with great distances in between, sometimes in larger floes or stripes. The individual plants are sometimes provided with a main axis, from which shorter lateral branches ramify or they are sometimes bushy with no definite main axis. As a rule they float on the surface of the water, being held up by the numerous bladders filled with air which are always present; they may drift along several metres beneath the surface, particularly the heavier plants, which, either because they have relatively fewer bladders, or because they are old and overgrown with epizoa, do not possess sufficient buoyancy to counteract the downward pressure to which the movement of the water often submits them. The colour of *Sargassum* varies from light olive-yellowish-green to brown. It is distributed in such a way that the point or top of the plant is light, while the lower, older parts are dark. The older parts are almost always overgrown with Bryozoa, *Spirorbis* and Hydroids. The latter are often present on the light coloured parts as well. The size of the plants varies from fragments a few centimetres large to bushes with a growth of several decimetres.

Sargassum is irregular in occurrence even in those areas where it is most frequent. Not that one may sail for hours without seeing a single *Sargassum*-plant, but at one time of the day one may see small fragments or tufts as big as one's hand, while at another time great floes or stripes of varying length and breadth appear. The stripes always follow the direction of the wind. Their length is often considerable. Mr. P. Jespersen while on board the m/s "Margrethe" observed a single stripe of sea-weed which the ship followed for 1¼ hours finally leaving the course of the sea-weed so that it could no longer be seen. "Judging by the speed at which the ship was sailing this stripe was at least 3—4 sea-miles in length".

Captain G. Hansen while a passenger on board s/s "Bintang" made daily notes on the occurrence of *Sargassum* on the route between St. Thomas and the English Channel. He computed the frequency by counting 1—3 times daily how many *Sargassum*-plants, large floes or stripes, the ship passed in 15 minutes. Let me quote a few examples of these ¼ hour observations: 1) 15 thin stripes with a few small tufts between. — 2) 35 very small plants and 2 very thin stripes. — 3) 20 large floes and 25 broad stripes; between the stripes quantities of small tufts. — 4) 47 very thin stripes; between these many small tufts and many single plants. — 5) 210 small scattered plants; single larger tufts and 12 very thin stripes. — 6) 65 rather large tufts; no stripes; a few single small plants. — 7) 25 large floes; 10 close stripes; between these many small tufts and many single plants. — 8) 85 rather thin but long stripes; in some of the stripes were some larger flats; among the stripes only a few plants. — 9) 120 quite thin but short irregular stripes; among these many small plants. — 10) 27 rather large flats; among these a few thin but short stripes; a great quantity of small tufts. Captain G. Hansen told me further that the greatest accumulation of *Sargassum*-weed he had ever encountered was on a voyage from Liverpool to Savannah. At a certain point of the route the ship was in a sea-weed floe so large that there was no open water visible on any side, and so compact that the furrow in the wake of the ship closed up a few hundred metres astern. Under such conditions the patent-log had to be taken in.

I have never seen any discussion of the fact that *Sargassum*, — and indeed all other drift as well, — often collects in great flats or long stripes, parallel with the direction of the wind; however the phenomenon seems to me explainable. The largest part of the body of a floating *Sargassum*-plant is beneath the surface of the water; only a few leaves and ends of shoots project above the surface. The direction in which these algae float is determined not only by the current but also by the wind, for the latter not merely influences the direction of the current in the surface water, but also that of the *Sargassum*-plants themselves, — for these, with their leaves sticking up like tiny sails, are borne along as the wind lists. A *Sargassum*-plant sailing in this way glides like a ship through the water leaving a wake behind. All other drift which this "ship" passes is sucked into its wake, and of course other sea-weed as well. On account of the bushy ramifications of these plants two that are contiguous sometimes become

interlaced with each others branches and form a unit. Under the continued sail some plants may overtake other more slowly moving plants which are either driven in advance or sucked into the wake, or it may in turn be overtaken by more quickly sailing plants. By degrees a considerable flotilla collects, stretching out in the direction of the wind. The stronger the wind and the faster the rate of speed at which the little fleet moves the more easily can it be broken up into several narrow ones, sailing faster or slower as the case may be. When the wind is gentle, the cohesion between the plants allows rather large, broad flotillas to form. The *Sargassum* stripes are quite often composed solely of unattached bladders, millions of which float on the surface of the water. This phenomenon is probably most common along the boundaries of the Sargasso Sea.

It seems indeed to be a rule that when the wind is strong the *Sargassum* sea-weed stripes are very narrow and lie close together. When the wind blows gently the stripes are broad with a larger respective distance between, whereas in calm weather large coherent iso-diametric flotillas are common. When the wind veers the stripes of sea-weed very quickly change their direction; they break up and the separate parts assume a new arrangement in the line ahead. This sailing flotilla comprises not only the algae themselves but also the mass of water between them. Such a flotilla forms indeed at little world of it's own having it's own extremely interesting animal life. The algae act as wave-subduers in that stretch of water which they surround. Seen from a distance in a breeze the *Sargassum*-flotillas lie like smooth stripes in contrast to the ruffled surface of the surrounding ocean.

The community of organisms which one may find in these *Sargassum*-flotillas is described in detail in the Report of the "Challenger Expedition"[1]. The most striking fact is the appearance of crabs and certain surface-fishes, peculiar to the Sargasso, which live among the fronds of the sea-weed. On March 6, 1873, at 20°49′ N., 48°45′ W. the expedition observed the following conditions (vol. I, page 194): "A good deal of Gulf-Weed drifted past during the day, and we were struck by the circumstance that a large portion of it, instead of assuming its usual loose graceful arrangement in the water, was in the form of round compact balls, a little larger than cricket-balls. A boat was sent off to collect some, and about half a dozen closely-twined bundles were brought on board. On pulling them to pieces and examining them we found that the bundles were bound together by very strong transparent strings of the viscid secretion of the singular pelagic fish, *Antennarius marmoratus*, and that the spaces among the fronds were filled with its eggs".

This same phenomenon has been repeatedly observed during the Danish expeditions to the Sargasso Sea and several of these peculiar, round or oblong balls of closely entwined algae, as much as 20 cm. long, have been fished up during the spring months, April and May. One wonders how a comparatively small fish succeeds in tying together the *Sargassum* with such strength as seems to be emplied here. It is likely though, that the growth of the algae, after their having been tied up, increases the compactness of the balls. To the egg-strings are attached rather large quantities of eggs, about 2 mm. in diam. and it is noteworthy that only two of the species of drifting *Sargassum* are found in the balls, i. e. the two species I and V which possess the smallest bladders (vide description of species, chapt. 5). The former is the principal constituent of the balls and very often the only one; but in surprisingly many cases we find the characteristic and rather rare species V with its specially small bladders; and the resemblance of the young bladders of said two species to the eggs is so great that the idea suggests itself that a protection of the eggs is aimed at by the choice of the two most appropriate forms of algae. In a single case only, I have observed the presence of a small sprig of the very common species III. — Although small individuals of *Antennarius* frequently hide in these *Sargassum* balls, the statement of the report on the "Challenger" expedition, that the eggs belong to this species of fish, is certainly erroneous. As far as Dr. Johs. Schmidt and the ichthyologists of his expedition have hitherto been able to judge, the egg-strings belong to Flying fish.

[1] Sir Wyville Thompson: "The Atlantic", Vol. I and II. London, 1877.

Barnacles are also found on *Sargassum* and quantities of smaller organisms. As has already been said the plants are often thickly covered with *Spirorbis*, Bryozoa and Hydroids. I have made no special effort to determine the species of all the epizoic forms which were found on the *Sargassum* in my material, but only of those which were very common or which were characteristic for certain types of *Sargassum* and wanting in others.

HENTSCHEL in his work (l. c. 1921) gives some special observations on the epizoa on drifting *Sargassum*.

Mr. P. KRAMP, M. Sc. has determined the following Hydroids:

Gemmaria costata (GEGENBAUR) usual territory the southern part of the eastern coast of North America, where this Hydroid is always found on floating *Sargassum*. The medusa is reported from off Messina.

Holecium nanum ALDER. Without gonosome. Formerly found on *Sargassum* throughout the North Atlantic Ocean and likewise on *Sargassum* in the Adriatic off Rovigno.

Campanularia (Clytia) cylindrica AGASSIZ. Without gonosome. Formerly found on *Sargassum* and on *Pennaria*, *Eudendrium*, *Alcyonaria*, and many other organisms. Found, too, on bridge-piles. Indigenous to the southern section of the eastern coast of North America as far north as Wood's Hole.

Campanularia (Clytia) noliformis MC CRADY. This very common form is known earlier from the Sargasso Sea, from the neighbourhood of the Bahamas, from the Gulf of Mexico and from the Atlantic coast of North America as far north as Wood's Hole. It is almost always found growing on *Sargassum*, but may be found on larger Hydroid-colonies as well. Mr. KRAMP states that he has found it in great quantities on the *Sargassum* washed ashore on the southern coast of St. Jan, one of the islands of the former Danish West Indies.

Laomedea (Obelia) hyalina CLARKE. Found in the same area as the above-named species.

Sertularia (Pasythea) quadridentata ELLIS et SOLANDER. With single gonothecae. This species is more widely distributed than those mentioned hitherto. It is not only found together with the above species on *Sargassum*, but in the South Atlantic, the Indian and the Pacific Ocean as well.

Monotheca Margaritta NUTTING. Same distribution as the other North Atlantic forms already mentioned: almost always on *Sargassum*.

Aglaophenia late-carinata ALLMAN. A very common form reported by many scientists from the North Atlantic Ocean. Always found on *Sargassum*. Mr. KRAMP states that this form, too, is found on the *Sargassum* washed ashore on the southern coast of St. Jan.

Of the forms mentioned here, *Campanularia noliformis* and *Aglaophenia late-carinata* are particularly common: It is curious that each is found on its own particular *Sargassum* species in the Atlantic Ocean. I will discuss this matter later in Chapter 5.

Most conspicuous and common of all the epizoic organisms on *Sargassum* is the Bryozoon *Membranipora tuberculata* which overgrows and incrusts the floating plants with a net-work forming an armour of lime.

Many small epiphytes, — *Rivularia* for instance, — are common.

In a single instance a parasitic fungus was found, a very conspicuous Ascomycete hitherto undescribed. I will discuss and describe it further at the end of this paper.

It was but natural to use the abundant material at hand in an attempt to chart the Sargasso Sea. We could not tell in advance how successful we would be in setting fast boundaries for that floating formation, but the result shows that the forces of wind and current determining the location of the Sargasso Sea are so constant that the boundaries could be partially fixed in any case.

I have already described the way in which the *Sargassum* samples were obtained; it excludes

Fig. 2. Chart showing the boundary of the Sargasso-Sea and the stations taken in the Sargasso Sea or in adjacent districts. The black circular spots indicate *Sargassum*. The greater the quantity of *Sargassum* in the samples, the larger are the spots. The circumferences indicate negative stations.

the subjective estimate, which, as has been shown, must have been dominant in KRÜMMEL's method of investigation. In working with so many samples it was easy to decide whether *Sargassum* was abundant and luxuriant at a given station or whether it was scarce. Both the number and size of the plants in the sample were factors in this decision.

In macking the chart the presence of *Sargassum* is indicated by a black circular spot, which is larger the greater the quantity of *Sargassum* plants in the sample. Negative stations are marked with circles. Many stations in the Atlantic Ocean which are very remote from the Sargasso Sea, and therefore negative, are omitted, but all the negative stations in the Sargasso Sea or in adjacent districts are included[1].

A study of the chart (Fig. 2), will doubtless show that the black line drawn toward the east and south may be considered the boundary of the Sargasso Sea for those points of the compass.

However it is a matter for judgment whether the boundary line should include a greater or smaller number of negative stations, thus excluding a greater or smaller number of positive ones. This is particularly true at the eastern end near the Azores where scanty occurrences appear quite far beyond the boundary line thus drawn. Yet the positive stations lying outside the boundary toward the east and north-east as a rule only showed brown fragments or detached *Sargassum*-bladders; this was also the case in some of the stations located just within the boundary-line[2].

While at 35° W. Long. *Sargassum* is not found S. of 27° N. Lat. and N. of 40° N. Lat., at 60° W. Long. its area extends as far as 19° N. Lat. Thus the southern boundary of the Sargasso Sea follows a line going east north-east—west south-west. A curious fact appears in the northern boundary of the Sargasso Sea, for south-east of the Banks of New Foundland is a stretch whose centre is about 52° W. Long. 39° N. Lat. where *Sargassum* is but rarely found. In conformity with this, the northern boundary line of the Sargasso Sea makes a bend at this point (see the chart). In the bay thus formed *Sargassum* was found at only 2 of the 25 stations; whereas west of this locality, *Sargassum* was quite frequent. This curious distribution must be due to the fact that the Gulf Stream carries drift-algae with it along the eastern coast of the United States in a north-easterly and finally easterly direction, while the cold fresh Labrador Current, coming from the north, penetrates the Gulf Stream at the upper layer of water. It is a matter of fact that the isotherms[3] of the surface-water indicates a bend at this point, though perhaps less pronounced than that appearing on the chart shown here. Here too, the conditions of temperature are not favourable for the development of *Sargassum*. I consider the bay in question a locality in which *Sargassum* is found so irregularly that it should not be included in the Sargasso Sea. — I have not been able to investigate in detail the western boundary of the Sargasso Sea from the material at my command. Yet it is very apparent that no drift-*Sargassum* is found close off the coast of the United States. This is a natural result of the fact that a branch of the Labrador Current in connection with the considerably colder and fresh waters of the Gulf of St. Lawrence push in between the Gulf Stream and the continent. In the most northern area of the Sargasso Sea, about 40° N. Lat. the occurrence of *Sargassum* is far less regular than in more southern latitudes. There is a distinct variation in its occurrence between summer and winter and between various points, for, as I have just said, the cold current coming from the north collides with the warm waters of the Gulf Stream and thrusts itself irregularly into the latter. KRÜMMEL was cognizant of this fact (see page 9). Only during the harvest and autumnal

[1] A complete list of the stations, with the exception of few about which I have obtained information myself, and a map on which they are indicated, may be found in JOHS. SCHMIDT: "Stations in the Atlantic, etc., 1911—1915". (Medd. fra Kommissionen for Havundersøgelser, Serie: Fiskeri, Bd. V. Nr. 7. Copenhagen, 1919).

[2] Coincident with this is a statement found in H. B. GUPPY: Plants, Seeds and Currents in the West Indies and Azores, London, 1917. The author writes, page 38: "..... living specimens did not come under my notice on the Azores beaches, the dead fragments, which are well incrusted with polyzoa having derived, not directly from the Sargasso Sea to the south-west but by the circuitous route to the northward, past Cape Hatteras, which is taken by the West Indian seed-drift", — and on page 485: "Sargasso weed seems to possess a fugitive vitality outside its usual waters".

[3] G. SCHOTT: "Geographie des Atlantischen Ozeans". Hamburg, 1912.

months does he find *Sargassum* north of 40° N. Lat. while at the converse season algae are wanting. "Reading" in this how *Sargassum*, coming from the neighbourhood of the coasts of the Bahamas like a tidal-wave, passes in the course of the summer the northernmost latitudes, only to rotate in a south-easterly and southerly direction during the winter and spring, he finds in it a circumstance which agrees with his theory as to the origin and life of the drift-algae. That this theory is not necessarily correct, — let me add that I do not think it is so, — will appear in what follows.

When we examine the meteorological charts of the North Atlantic Ocean for the various seasons of the year[1], we find that in that area of the ocean lying north and north-east of Bermuda and extending up to New Foundland, the prevailing winds during the summer (July), are from the south-west, while during the winter (February), they are from the north and north-west. This very great difference in wind-direction must of course influence the drift of *Sargassum*. During the summer drift-algae are carried towards the north-east by both wind and current; during the winter, however, the northern and north-western winds carry the algae further towards the south, mostly in a south-easterly direction.

In other words, it is not necessary to claim the help of KRÜMMEL's theory of an annual tidal wave of recently detached *Sargassum* plants, in order to understand why *Sargassum* is found north of 40° N. Lat. only during the autumn. Even though no new supply of *Sargassum* comes from the coast, the condition would be exactly the same. The northern boundary of the Sargasso Sea changes according to the direction of the prevailing winds, — in the summer further north, in the winter further south.

Not only then, is KRÜMMEL's theory unnecessary in order to understand the more abundant occurrence of *Sargassum* during the summer north of 40° N. Lat., but, using KRÜMMEL's own material we are able to prove its incorrectness. If his theory were correct, the western area of the Sargasso Sea, including the Gulf Stream would contain more *Sargassum* in summer and autumn, while the eastern and more particularly the south-eastern area, would first show a maximum occurence of *Sargassum* during the winter and spring. KRÜMMEL himself computes that of recently detached *Sargassum* plants with the power to drift, those detached from the rocks along the coasts of the Bahamas in July would have reached the Azores about $5^{3}/_{4}$ months later, that is to say, in December. In order to investigate this fact further, I have examined the KRÜMMEL-ANTZE seasonal frequency-percentage for the entire Sargasso Sea and the area nearest or south of the Azores respectively. On the chart, Fig. 1, a zig-zag line is drawn dividing the Sargasso Sea into longitudinal and latitudinal degrees divisible by 5. According to KRÜMMEL's statements the area east of this zig-zag line must contain the largest amounts of drift-algae during the winter and spring. This may be investigated by a simple addition of all the spring-, summer- and other frequency percentages in the entire Sargasso Sea and by comparing the result obtained with that obtained by adding the seasonal-frequency percentage for the 5° sections lying east of the line drawn.

	Sum of frequency-percentages			
	Spring	Summer	Autumn	Winter
For the entire Sargasso Sea	159.5	148.9	189.6	177.2
For the area east of the zig-zag line in Fig. 1	64.1	58.3	76.3	71.0

As the entire area of the Sargasso Sea according the KRÜMMEL-ANTZE chart includes 45 5° sections, while the eastern area only includes 18, the figures may be more readily compared by multiplying them in that proportion, that is to say by multiplying the upper row of figures by 2, the lower by 5. We then find:

	Spring	Summer	Autumn	Winter
For the entire Sargasso Sea	319	298	379	354
For the area east of the zig-zag line in Fig. 1	320	291	381	355

[1] For example, U. S. Weather Bureau's Meteorological Chart of the North Atlantic Ocean, — or Deutsche Seewarte's Monatskarte für den nordatlantischen Ocean.

We see from the above, first, that *Sargassum* is observed with relatively equal frequency east and west of the line, and secondly, that the area east of the zig-zag line shows no particularly abundant *Sargassum* frequency in the winter or autumn months in comparison with the remaining area. Yet there is system in the occurrence-frequency of *Sargassum* in the various seasons. From summer to autumn the amount of *Sargassum*, as we see, increases considerably[1], diminishing gradually again during the winter spring and summer at which latter season the minimum is reached. This condition prevails in the south-eastern, eastern and western areas, and I do not doubt but that the suddenly increasing frequency of *Sargassum* during the propitious season is due to the fact that *Sargassum* grows vigorously during the summer. This will be discussed further in a following chapter.

The boundary for the occurrence of *Sargassum* towards the west and south-west is not indicated on my chart as the observations here are, as I have said, too few. Yet there is no doubt but that the line ought to continue, following the eastern coast of North America, close off the land. Whether or not it should include the chain of islands of the West Indies is an open question. There are several "negative" stations close off the Antilles, and therefore the frequency there must be less. However, as much *Sargassum* (typical oceanic forms), is washed ashore on the southern and western coasts of the former Danish West Indies, we may judge that it is quite frequent in the northern area of the Caribbean Sea.

KRÜMMEL's chart of the Sargasso Sea differs, then, somewhat from mine. Most striking is the fact that KRÜMMEL's 10 % curve does not pass closer to the Azores for, as is seen, great quantities of *Sargassum* have often been fished up here. If we examine the KRÜMMEL-ANTZE chart (Fig. 1) we find no reason for not including more 5° sections in the curve showing the greatest frequency. 5° sections with average annual frequency of 9.4, 7.5, 4.3 are excluded from KRÜMMEL's chart, while the sections towards the west with frequencies of 1.9, 4.6, 5.4, 5.3 etc. are included in the 10 % curve. This is explicable by the fact that in 1891 when KRÜMMEL drew his chart of the distribution of *Sargassum*, he had not fully worked over the Deutsche Seewartes material, which was indeed first completed by ANTZE in 1901. KRÜMMEL's various curves showing *Sargassum*-frequency must then be considered only fairly correct, based as they are on a material which did not at that time permit the author to go further into detail. KRÜMMEL's curves are in the form of ellipses with the longitudinal axis parallel with the equator and seemingly drawn rather by chance with "free hand". It is no easy matter to fix fast boundaries for drift which is subjected to the influence of wind and current. Yet my investigations have convinced me that the south-east boundary of the Sargasso Sea in particular varies but little[2], and that it lies as shown on the chart; just as the remaining boundaries for the occurrence of *Sargassum* as conspicuous drift are as correctly given as it is possible to draw them.

The directions of wind and current in the *Sargassum* area of the North Atlantic Ocean as shown on the meteorological charts agree with those indicated by the curves on my chart. The surface water and the drift floating in it is, everywhere in the periphery of the *Sargassum* area, whirled by wind and current slantingly in toward the centre of the current, thus bringing about a rotary motion following the hands of a clock. Judging by the direction of current and wind as shown by the arrows, *Sargassum* is able to escape from its area and be carried towards European shores only north-west of the Azores during the spring months.

Yet the chart shows that not a single *Sargassum* plant has been found off the coasts of Europe; all the stations east of 20° W. Long. are negative.

KRÜMMEL's assumption that *Sargassum* can drift with the current from the Atlantic Ocean into

[1] Strictly speaking, the figures only indicate that *Sargassum* is observed much more frequently during the autumn. As has already been said, it is doubtful whether the number of observations made are entirely independent of the seasons with their varying light and climatic conditions. Yet there is no doubt but that the figures indicate actual conditions, for if the length of the days had a decisive influence on the number of observations, the summer months would show the greatest frequency, the winter the smallest, but this, as the figures indicate, is not the case.

[2] The report made by COLUMBUS 4—500 years ago on the most eastern appearance of *Sargassum*, coincides exactly with the line of the curve.

the Mediterranean has not been proved by my investigations, and the same is the case with Dr. JOHS. SCHMIDT's observations[1] concerning *Sargassum:* "This bottle together with some drifting Sargasso-weed in the Western Mediterranean is direct evidence that floating bodies can be carried into the Mediterranean from remote places in the Atlantic". The *Sargassum* plants found in the Mediterranean have certainly nothing to do with the algae of the Sargasso Sea, but belong to special types.

There is no doubt but that the reason why *Sargassum* does not reach the coasts of Europe alive is that the temperature of the surface-water is too low. Judging by all outward signs *Sargassum* cannot thrive in a temperature lower than 18° C.; not that it is instantaneously killed when subjected to a lower temperature but its growth gradually ceases, it becomes sickly and the epizoa clinging to the plant soon grow faster than the plant itself thereby further weakening its power of assimilation. Already near the Azores, where the temperature of the surface-water[2] varies from 15°—23° according to the season of the year, dying or dead fragments of *Sargassum* are the rule. In the Sargasso Sea, itself, the temperature of the water is considerably higher, varying from about 20°—28° according to the locality and season of the year. To reach the coasts of Europe *Sargassum* must be able to endure a temperature of 15°—10° during many months, which it is far from being able to do, and to penetrate the Mediterranean Sea it would be subjected, even under the most favourable conditions to a temperature of 18°—15° during long periods, as, on account of the conditions of the currents, it is only able to reach Gibraltar by a northern route. Another reason why the algae of the Sargasso Sea cannot thrive in the Mediterranean lies in the fact that here the temperature is below 18° the largest part of the year, and during the winter months it is 12°—13° C. or lower, except in the eastern part.

4. The growth and biology of Sargassum.

We have already spoken of the various theories in regard to the origin and biology of drift-algae, (Chapter 2). We found there that only the older investigators considered Gulf-weed able to grow and propagate while floating about. More recent scientists claim as rule that even though the *Sargasso*-weed grows a little, the growth is abnormal and the plants soon die. We find an example of this theory in MURRAY and HJORT[3], (page 336): "The Sargasso weed continues to grow as it drifts, but the gas-bladders are not formed in the same proportion as on the ordinary branches, the result being that one finds newly detached patches close up to the surface, whereas the older patches with a greater specific weight have sunk lower down. These last have, moreover, thinner branches and a lighter olive-brown colour. Finally, the power of floating ceases altogether, and the patches sink into deeper water and perish. Their disappearance is, however, quite imperceptible, since fresh patches of weed are constantly arriving from the coast".

KUNTZE[4], as I have suggested, scouts the possibility of drift-algae leading an independent existence in the Sargasso Sea, and his work contains many statements which I consider misleading.

He writes (l. c. page 197): "Übrigens habe ich bei den vielen Hundert von mir revidierten Herbarienexemplaren des *S. bacciferum* keine Spur davon gesehen, dass sich aus den Zweigspitzen oder sonst an der Pflanze eine neue Pflanzenverzweigung oder Knospe entwickelt hätte; die betr. Angabe hat also gar nicht die geringste Glaubenwürdigkeit für sich".

[1] "Experiments with drift-bottles" (Report on the Danish Oceanographical Expeditions, 1908—1910. Vol. III, No. 1. 1913).
[2] G. SCHOTT: "Geographie des Atlantischen Ozeans".
[3] "The Depths of the Ocean", London, 1912.
[4] "Revision von *Sargassum* und das sogenannte Sargasso Meer" (A. ENGLER: Botan. Jahrb., vol. 1, 1881, p. 191).

In refutation of this proposition let me quote a statement written in a letter, March 17, 1914, by Professor, Dr. C. H. OSTENFELD whose great biological insight no one who is acquainted with his many biological studies will question. On an expedition to the former Danish West Indies, Professor OSTENFELD made biological investigations of the *Sargassum* in the Sargasso Sea, to show, among other facts, to what extent *Sargassum* was able to grow while drifting. He writes: "There is no doubt but that *Sargassum*-shoots grow rapidly while drifting. The lower part of an "individual" is generally brown and well overgrown with *Membranipora* and *Spirorbis*, the upper part is light olive yellowish-green, but little overgrown, and mostly, with Hydroids. Vegetative propagation takes place by storms and the action of waves detaching portions of the shoots, which then continue their existence as independent individuals. It is not necessary that all *Sargassum* come from the coast, if only some is detached and washed adrift from time to time, it will multiply of itself".

Mr. JESPERSEN, M. Sc. who, as has been said, took part in the Deep-sea Expedition of the "Margrethe", and who has cruised in the Sargasso Sea months at a time in order, among other problems, to answer many questions concerning the biology of *Sargassum*, which my investigations had brought up, expresses himself in a similar way. "There is no doubt but that *Sargassum* grows in the ocean. Young shoots, that is to say delicate and lighter small branches, are often found".

I too, after studying the comprehensive material placed at my disposal and preserved in a formaline solution, had already the impression that *Sargassum* grows at a lively rate in the ocean. How else explain the fact, also noted by OSTENFELD, that the upper ends of the shoots in contrast to the lower ends, are not overgrown with epizoa, if it was not because the very growth of the algae produced new parts as yet unattacked? It is indeed a fast rule that the light colored shoot ends are never covered with *Membranipora*, whereas Hydroids, which, plainly enough, have a quicker growth, can be found quite near the ends of the shoots. The *Membranipora*-colonies encountered nearest the extremities of the shoots are always quite diminutive and increase in size as they approach the older parts which at the base are often entirely incrusted. Such behaviour on the part of the epizoa is sufficient in itself to indicate the growth of *Sargassum* and thus disprove KUNTZE's theory.

In his work (l. c. 1921, pag. 24), HENTSCHEL mentions that he has made this identical observation and this, as well as other circumstances, has led him to conclude as follows: "Ich habe in der Tat die Überzeugung gewonnen, dass dies für die Hypothese der Selbständigkeit des Hochseesargassums, wenn nicht der absoluten, so doch einer sehr hochgradigen, zutrifft" — and further (l. c. page 25): "Nimmt man diese Gründe nebst den von den Botanikern aus dem Zustande des *Sargassums* selbst hergeleiteten als stichhaltig an, so wird man dem Satze zustimmen, dass das treibende Golfkraut mit seinem Bewuchs wahrscheinlich eine reine Hochseeformation, jedenfalls aber nicht bloss eine auf die Hochsee verschlagene Küstenformation ist".

He is thus the only one of more recent scientists to consider *Sargassum* as vegetatively growing and living in the Sargasso Sea.

A link in KUNTZE's chain of evidence for the argument that the algae in the Sargasso Sea are only drifting fragments of plants detached from the coasts, lies in the following statement (l. c., page 195): "Am Strande wachsend sind die Blätter aufwärts gerichtet und überragen die nächsten daneben befindlichen Blasen; letztere stehen also tiefer als die Hauptmasse des Blattes. Wird nun aber der Zweig abgerissen, so dreht sich die Stellung meist um, weil die Blasen oben schwimmen und die längeren und specifisch schwereren Blättermassen abwärts sich richten. Diese abnormale Stellung der Fragmente im Ocean, die ich selbst mehrfach beobachtete und die mir von verschiedenen Reisenden auf meine direkte Anfrage als die gewöhnliche bestätigt wird[1], widerlegt allein schon die von

[1] KUNTZE's foot-note "..... BURMEISTER, Reise nach Brasilien, S. 562 behauptet zwar auch hier mit grosser Bestimmtheit dass Gegentheil; — es sollen seinen zahlreichen Untersuchungen (?) zufolge die Büschel vorherrschend aufrecht mit dem dicken Stengelende nach unten schwimmen — aber diese seine Angabe, welche in der Literatur vielfach Aufnahme fand, ist ebenso falsch, wie....." etc.

manchen Reisenden verbreitete und fast zum Lehrsatz gewordene Vermuthung, dass das Golfkraut eine selbständige Pflanze des Oceans sei, denn keine lebende Wasserpflanze wächst mit aufgerichteten basalem Stengelende und abwärts gerichteten geraden Blättern und Zweigspitzen".

On account of KUNTZE's theory I requested both Professor OSTEHFELD and Mr. JESPERSEN before they left, to take special note of this state of affairs while on the expedition; both reported that the plants normally float with the extremities of their branches upwards (or outwards) and with the older part of the stem downwards (or inwards). The movement of the water can sometimes of course turn the plants upside down.

One of the most important arguments in favour of the theory that drifting Sargasso-weed does not come directly from the coasts, is to be found in the fact that these plants according to several concordant observations, have never developed sexual organs, whereas these are constantly found on the attached coastal forms.

KUNTZE writes on this matter (l. c. page 197): "Es ist allerdings fast Regel, dass die Fragmente im Ocean ohne Receptakel sind; ich habe indess verschiedene Exemplare auch mit Receptakel vom hohen Ocean gesehen und einige auch mit phototypieren lassen. (Nr. 3. u. 5.)".

In this matter too, KUNTZE's position is distinct. I cannot accept his positive statement that sexual organs are present, for I maintain with great certainty that the two phototyped specimens which he prints as documentary evidence in this matter, have not been collected in the Sargasso Sea far from the coasts. The close bushy appearance of these specimens indicate that they are individuals of the characteristic West Indian attached type. I have never seen freely floating individuals of like appearance in all the extensive material with which I have worked, nor has Mr. JESPERSEN, in his special investigations of the Sargasso Sea succeeded in finding any. I mention this merely to call attention to the fact that the specimens from the herbaria at KUNTZE's disposal must have become interchanged.

However, drifting, fructifying *Sargassum* individuals are really found, occasionally; but then they belong to species which are not spread over the entire Sargasso area but only in the far western part; and it is probable that such individuals have only recently drifted out from the coast. It is a matter for judgment whether such forms which, differing in this from all the other forms, are never found in the eastern parts, should be considered as belonging to the algae population of the Sargasso Sea. From personal experience, I rather favour the opinion that the algae really belonging to and growing in the Sargasso Sea never fructify.

However, the possibility that single freely floating and growing specimens with receptacles may be found as a great rarity is not totally excluded. Yet, even though such a single specimen were found, the presence of receptacles does not prove the specimen to have been attached.

There are so numerous and so incontestable proofs that most of the algae in the Sargasso Sea live and propagate there, that it seems unnecessary to mention others. However, the many statements, — particularly KUNTZE's, which is made with a great degree of positiveness, force me to ask again what other condition can explain the considerable increase of *Sargassum* everywhere in the Sargasso Sea during the summer, which, based on KRÜMMEL's figures seems considerable, and to which I have referred, page 16, if it is not an annual period of growth coincident with the warmest season of the year? Finally, too, let me ask why no one has hitherto succeeded in demonstrating where the *Sargassum*-types drifting about in the Sargasso Sea, grow when attached? If the drifting plants came from the coasts of the West Indies and the Bahamas, and had only floated about for a short time, a few months at most, without any appreciable growth, then these drifting plants must have a similar appearance to some one or other attached coastal form so common and abundant along the coast as to be known to everyone. This is far from being the case. Quite the contrary; for up to the present time of writing no one knows where "*Sargassum bacciferum*" grows attached, though the *Sargassum*-types on the coasts in question have been well studied. If it should be found on the tropical or sub-tropical American coasts of the

ocean, the form when attached, in spite of its identity must have a very different appearance from the floating form which is readily distinguished from all attached forms. We must conclude then, that the floating form grows and assumes by degrees a very changed outward appearance.

I hope this discussion will silence once for all the many assertions that the common types of *Sargassum* floating in the Sargasso Sea do not grow and live as independent plants, nor yet as normal *Sargassum*-plants, for the sexual way of propagation is wanting.

5. Taxonomy of the drift-algae found in the Sargasso Sea.

While there seems to be no difficulty in referring the brown-algae found in the Sargasso Sea to a definite number of types, it is impossible to classify the *Sargassum* species according to the attached coastal forms, hitherto known. It is a well-known fact that drift-algae can assume a phenotype, quite different from the normal, attached types, wherefore it is not surprising that the types found in the Sargasso Sea are not too easely identified with some of the coastal forms. Only experimental investigations can raise the veil of mystery surrounding the drift-*Sargassum* types. There would be no difficulty in carrying these out. As the types of *Sargassum* constantly present in the Sargasso Sea and in all parts of same, without exception lack organs of fructification, and the presence of these organs is necessary in order to determine the species, said organs must be brought into existence. This might be done by artificially fastening specimens belonging to the various drift-types to the coast, — for instance in the neighbourhood of the Bahamas. The individuals would thus be brought back again to the conditions under which they are supposed to have originally lived. It is probable that those sexual organs would develop on the transplanted individuals, which are normally characteristic for the attached coastal type; the plants would on the whole reassume their original appearance, and it might then be possible to state positively to what extent the drift-types are identical with the attached types. Until such experiments have been made, discussion of the matter is quite fruitless. No positive result can be reached either by theorizing or by studying herbaria.

During the last years, I have received, mostly from the 1921 "Dana" expedition, a series of *Sargassum* samples from the regions to the north and west of Bermuda from where material has previously been somewhat scarce. As said before, the stations concerned have not been laid down in the chart, Fig. 2. Among these samples, types were found which had not, or only rarely, been observed in my former material, and as these types are frequent only in the western regions, and especially in the Gulf Stream, it is permitted to surmise that they are coastal algae which winds and currents have carried out into the ocean. This is so much the more probable as they often carry receptacles and, occasionally, — 76°00′ W. Long., 33°30′ N. Lat. — the basal disc by which the alga has been attached to the rock. — Such types could probably, with some chance of success, be identified with known forms of coastal algae. Considering the existing disparity in the denomination of the different *Sargassum* types in literature, I have, however, not made any attempt to identify said types but prefer to leave this task to specialists in algology. In the present paper, all the *Sargassum* types have been designated by a current number. Future research and experiments will show whether it is possible to identify these types with known coastal forms.

I have found 8 different drifting *Sargassum*-species in the Sargasso Sea. These will be described in the following. Only by exception is there any difficulty in distinguishing between these 8 types. In

Fig. 3. *Sargassum I.* Typical specimen. Nat. size.

1913 Mr. JESPERSEN, who had taken with him on the "Margrethe" expedition in the Atlantic Ocean, my description of 5 of these forms, wrote in a letter from Bermuda that he had been able to identify the forms without difficulty. No. 6—8 which I had not yet found in the material placed at my disposal were brought back by Mr. JESPERSEN himself, or were found during the "Dana" expedition 1920—21.

Nine years ago in a lecture on the Sargasso Sea which I gave at a meeting of the Danish Botanical Society, (Dansk Botanisk Forening) Nov. 5, 1913[1], I stated that there are 2 principal species of drift-algae in the Sargasso Sea, *S. bacciferum* and *S. vulgare.* The former is most common; a special form of this species lacks points on its bladders, and may possibly, (according to Professor YENDO) be considered an independent species, — *S. Chamissonis.* 2 other *Sargassum*-species, which Professor YENDO has determined as *S. Liebmanni* and *S. myriocystum* are more rare, as is the larger alga, *Ascophyllum nodosum.*

I consider 3 *Sargassum*-types, denominated species I—III, as characteristic of the permanent, living Flora of the Sargasso Sea. Accessorily, there are 5 other types, i. e. species IV—VIII, which, in principle, are only found in the western regions. On account of their habitat and somewhat rare occurrence, the latter may be supposed to be identical with existing coastal forms. The existence of receptacles in some of these types tends to show their recent arrival from coastal districts. — Further, these latter types, and especially species V, are undoubtedly able to live, when drifting, through several months, even if species V does not possess as strong a capacity for growth and propagation as species I, II and III.

A description of the appearance of the floating *Sargassum* species in question follows; the most common are mentioned first.

Sargassum I. (Fig. 3—4). Determined by Professor YENDO as *S. bacciferum* (Turn.). Positively identical with *S. baccif.* C. AGARDH. Named by BÖRGESEN[2]. *S. natans* (L.) var. *ciliata* BÖRGESEN.

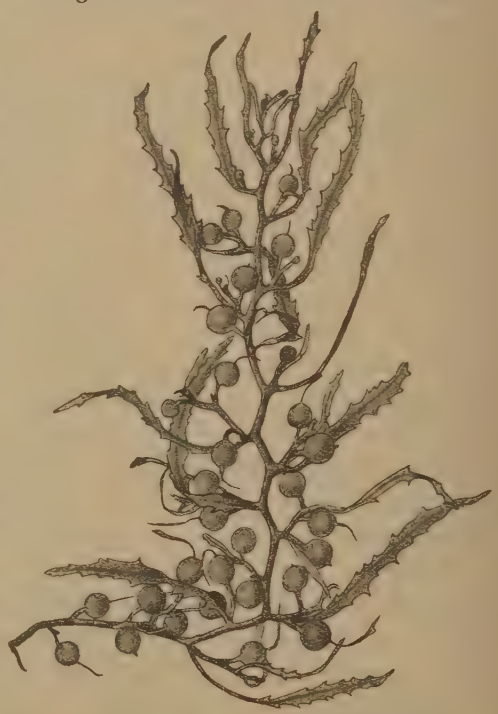

Fig. 4. *Sargassum I.* Less typical specimen. Bladders partly without apical prolongation. Ramification more open, and the leaves more slender than in the specimen on Fig. 3. Nat. size.

[1] See report of same in Dansk Botanisk Tidsskrift B. 33, S. 269.

[2] "The species of *Sargassum* found along the coast of the Danish West Indies with remarks upon the floating forms of the Sargasso Sea", (Mindeskrift for Japetus Steenstrup, Copenhagen, 1914):

The author closes his article with the following: "Since the printing of this paper was nearly ended Mr. WINGE has published a small note on the Gulfweed in the last number of the "Botanisk Tidsskrift", Vol. 33, Heft 4, p. 269. Having not seen the Sargasso Sea himself, Mr. WINGE's observation is not based upon material collected by himself. His results are: 1) The Gulfweed essentially consists of two species: *Sargassum bacciferum* and *S. vulgare,* 2) The *Sargassum* can surely float for some time and reproduce vegetatively. Finally some information is given about the location of the Sargasso Sea".

I make the following statements in this connection 1) I have not "pub-

This very common type is characterized by its linear, remotely serrate leaves, always lacking cryptostomes, and by its globular-ovate or obovate bladders, which are supplied with a protracted point. Sometimes some of the bladders lack the apical prolongation. The bladder-stalk is slender and thin, often exceeding the diameter of the bladder in length. The formation of dwarf-shoots and ramifications is so abundant that the plant appears bushy.

Of epizoa, besides the everywhere common *Membranipora tuberculata* and *Spirorbis* the one most commonly found is *Campanularia noliformis*.

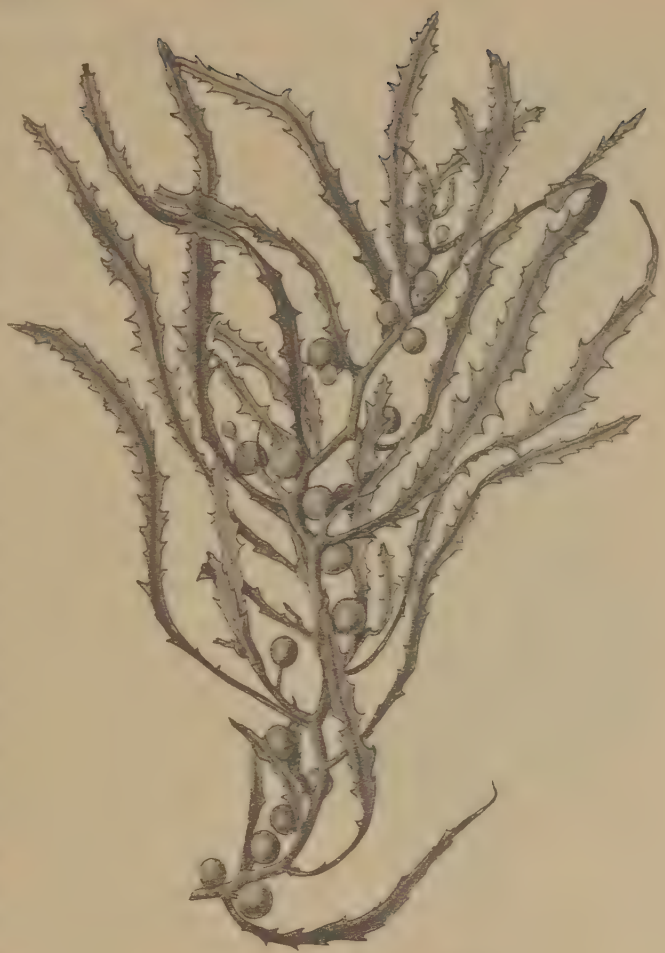

Fig. 5. *Sargassum II.* — Nat. size.

Sargassum II. (Fig. 5). Determined by Professor YENDO as *S. Chamissonis* KÜTZ. with the following addition: "J. AGARDH combines this species to *Sarg. bacc.* and both forms are found in his herbarium under the latter name. But it seems to be an upper portion of *Sarg. pteropleuron* GRUN". — It is undoubtedly identical with *Sarg. bacciferum* (TURNER). — BÖRGESEN (l. c.) designates it *S. natans* (L.) var. *typica* BÖRGESEN.

It resembles the preceding species and is almost as common. Differs in being more vigorously developed in all its parts. The bladder-stalk is usually shorter and thicker than in *Sarg. I*, and the bladders always lack the apical prolongation. The branches stand out nearly at right angles from the stem. The ramification and formation of dwarf-shoots is less abundant, giving the plant a more open appearance. The colour is lighter than that of *Sarg. I*. *Campanularia noliformis* is likewise common on this species.

Fig. 6. *Sargassum III.* — Nat. size.

Sargassum III. (Fig. 6). Determined by Professor YENDO as *S. vulgare* AG. I identified this form first as *S. Hystrix* AG. after an herbarium specimen of that name found in the collection of the Botanical Museum and determined by J. AGARDH and without doubt identical with the floating form. However AGARDH's identification must have been incorrect; in any case it agrees but poorly with the figure of *S. Hystrix* on Plate 7 in J. AGARDH's, "Species Sargassorum Australiae". Therefore I preferred the name *S. obtusatum*, under which designation O. KUNTZE (l. c.) describes and pictures the species in question. BÖRGESEN (l. c.) calls it *S. Hystrix*

lished a small note", but, as mentioned above, I have given a lecture on the Sargasso Sea in the Danish Botanical Society as early as November, 1913. 2) I did not draw the conclusion that *Sargassum* can float "some time", but that it floats "a long time"; I spoke of annual periods of growth. 3) BÖRGESEN's paper contains no new facts concerning the Sargasso Sea.

Ö. W.

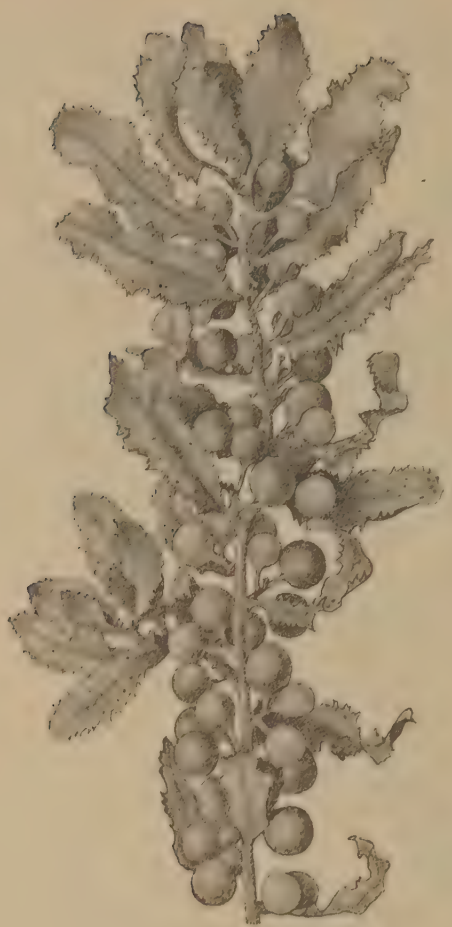

Fig. 7. *Sargassum IV.* — Nat. size.

var. *fluitans* BÖRGESEN, and this same author[1] finally specifies it as a new species, *Sargassum fluitans* BÖRGESEN.

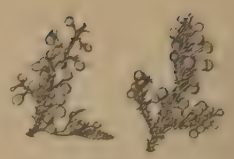

Fig. 8. *Sargassum V.* A small branch. Nat. size.

Sarg. III. is quite common throughout the Sargasso Sea, though not so common as the two foregoing species. The leaves are broader, most generally oblong, rather fleshy, less sharply serrate or with an irregularly waved edge; sometimes the edge is smooth, and then the leaves are linguiform. The leaves are generally supplied with cryptostomes, as a rule with a row on each side of the central rib. The bladders, which lack apical prolongation, are larger than in the preceding species; when full-grown they are often 7 mm. or more in length, generally slightly oblong, and arranged in clusters of 2—3 in the axils of the leaves. The bladder-stalk is short and thick. The stem is usually furnished with small scattered thorns, sometimes blunt, sometimes sharp. The entire plant makes a thicker, more solid impression than the two species first mentioned.

As a curious specific character let me state that this plant, in contrast to all other drift-*Sargassum* species, — is always over-grown with the easily recognizable pinnate Hydroid, *Aglaophenia late-carinata* (see Fig. 16), which I have already discussed in my lecture (1913) referred to above, (see the report). I have only found this Hydroid on *Sarg. II* a single time, while *Sarg. III* lacks the Hydroid only by exception.

The observation of HENTSCHEL (l. c. 1921, p. 10) that a specific difference exists between the epizoa living on broad-leafed and on narrow-leafed *Sargassum* plants is in agreement with the above.

Sargassum IV. (Fig. 7). This species has been determined by Professor YENDO as *S. Liebmanni* J. AG. with, however, the following addition: "N.B. The specimen does not agree satisfactorily with the originals and the determination is hence provisional".

Sarg. IV. is easily recognizable, but rather unusual in the Sargasso Sea. The leaves are broader than those of *Sarg. III*, oblong elliptical, thin, tough, closely and irregularly lobate-fringed, supplied with scattered cryptostomes. The bladders are numerous, globular, often large, with thin stalks, sometimes supplied with one or more scattered thorns or points. The stem has also scattered, thin, slack, sometimes ramified thorns.

Sargassum V. (Fig. 8—9). Determined by YENDO as *S. myriocystum* J. AG. with the following addition: "As the specimen lacks the leaves, the exact determination is rather difficult. But no such form as the present,

Fig. 9. *Sargassum V.* A large specimen, with scaphidia. — Nat. size.

[1] "The Marine Algae of the Danish West Indies", Copenhagen, 1914, P. 222.

so far as I could refer to, has ever been reported from the Sargasso Sea. If the present determination has been rightly done, the occurrence of the present species which is an inhabitant of the Indian Ocean, in the tropic part of the Atlantic should be much interesting".

This species is the most remarkable of all the species of the Sargasso Sea, but it does not occur in considerable quantities and is found most in the western region. In most cases its appearence is that represented in fig. 8, i. e. diminutive individuals with exceedingly small bladders, about 2 mm. in diam., closely clustered on long stalks. The leaves, when at all present, are few and small, — in the individuals analyzed by YENDO, they were entirely lacking; they are lanceolate, serrate and amply provided with cryptostomes. The stems are thin, with close-sitting long thorns. The colour of the plant is light.

Later on I have found the same species in the Gulf Stream tract to the north and west of Bermuda, but much more richly developed (Fig. 9), the plants being sometimes more than 40 cm. long with bladders up to 5.5 mm. diam. The leaves sometimes attain a length of 28 mm. but their width does not exceed 2 mm.; the midrib as well as the edge are often dentate-sinuate so that their cross section may be almost quadrangular. The smaller the bladders, the longer are their stalks — evidently a physiological phenomenon connected with the formation of the youngest and smallest bladders during the drift period of the plant. Receptacles have repeatedly been observed in this species; these are slender-cylindrical, ramified and nodose.

It is of the species here described that small fragments have been found knitted together with species I in the aforementioned algae-balls made by Flying fish (?).

Fig. 10. *Sargassum VI.* A branch from a larger plant. Nat. size.

Sargassum VI (Fig. 10) resembles to some extent in outward appearance the West-Indian coastal form described by BØRGESEN (l. c.) as *S. vulgare* C. AG. Exclusively observed in and near the Gulf Stream domain where it has repeatedly been gathered in hand nets.

Measured along the main axis, it sometimes exceeds 50 cm. in length; it has lateral shoots of about 15 cm. length, each with numerous short shoots, length about one cm., starting from every axil. The leaves are sessile, oblong-elliptic to linguiform, the edge either erose-undulate or serrate, sometimes almost without cryptostomes, sometimes with 1—2 rows along the edge of the leaves. The leaf base is frequently asymmetrical, the bladders numerous without apical extension. Receptacles have been observed; same are cylindrical, ramified.

The species is easily recognized by its close sitting, leafy short shoots on the branches. Frequently only one branch of the plant is collected which, in that case, is cylindrical.

This plant differs from the West Indian coastal form designated above as *S. vulgare* C. AG. (it may well be compared with the variety *foliosissima* (LAMX.) J. AG.) in that its leaves are not tortuous.

Sargassum VII (Figs. 11—12). Found in the Gulf Stream, but in scarce distribution only. The plant may reach a length of 1 metre, scatteredly branched, often apparently leafless because the leaves are so narrowly linear-filiform that they may resemble stems. They are smooth-edged or 4-sided serrate, not flat. The bladders are numerous, often large, as much as 11 × 9 mm., oviform—oblong, with thin walls and thin stalks. The stem spotwise thorny. Plants often of dark colour.

Sargassum VIII (Fig. 13). Found only a couple of times in northern part of Gulf Stream territory, south of New Foundland. — Most resemblance to species III, but more vigorous and larger; thorns and

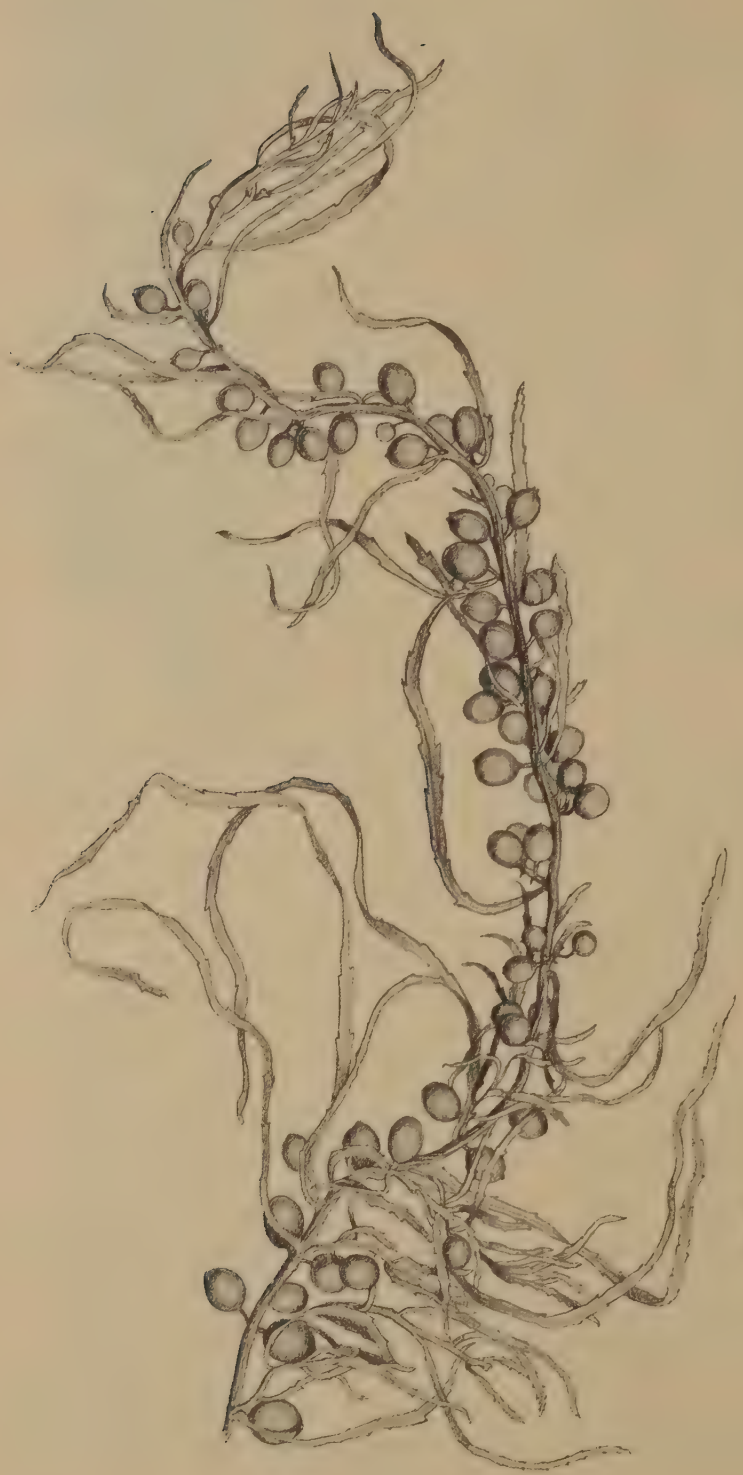

Fig. 11. *Sargassum VII.* — Nat. size.

Fig. 12. *Sargassum VII.* — Nat. size.

the epizoon *Aglaophenia* are lacking. The plant bushy, more than 30 cm. long. Leaves about 40—55 mm. long, 6—10 mm. wide, coarsely irregularly serrate, shortstalked. No cryptostomes were observed. Bladders 5.5—6.5 mm. diam., mostly single on rather long stalks.

Fig. 13. *Sargassum VIII.* — Nat. size.

Besides these species already mentioned several fragments of ***Ascophyllum nodosum*** (L.) Le. Jol. (Fig. 14) have been found occasionally. A specimen supplied with scaphidia was taken on Jan. 3, 1912 at a point lying at 43°42′ W. Long., 36°22′ N. Lat. Professor Kolderup-Rosenvinge, Ph. D. writes of this specimen that the sexual cells are not yet ripe, and that *Polysiphonia fastigiata* was found attached as an epiphyte. He adds, "..... the plant cannot have drifted very long (many months) in the ocean". Presumably this individual could have reached the locality in question in the course of 2—3 months, supposing, as is probably the case, that it originated from the most northern Atlantic coast of the United States. *Ascophyllum* is, indeed, only found in the northern area of the Sargasso Sea, — according to Mr. Jespersen's observations, preferably in the territory of the Gulf Stream where it occurs quite frequently. Only on a single occasion did he find it in more southern waters, namely near the Azores. — Another specimen, about 60 cm. long with young scaphidia and in fresh condition was taken at 37°46′ W. Long., 42°18′ N. Lat. in August 1920

As I have already stated I will refrain from a detailed discussion of the possibilities of the origin of the floating *Sargassum* species. It seems to me possible that the Central and North American *Sargassum Filipendula*, of which I have received a large supply preserved in formaline solution from Dr. Hugh M. Smith, Washington, D. C. is identical with *Sarg. I*, even though the last mentioned is much smaller than *S. Filipendula*, and moreover differs from it in having bladder points, and in other details.

Professor W. G. Farlow, with whom I corresponded on this matter in 1912 and 1913 writes among other matters in a letter dated March 30. 1913: "Between Cape Cod and New Foundland there is absolutely no species of *Sargassum* known. The records which mention *Sargassum* in that region are very few indeed and they are errors which have crept into the literature. The records of the gulf weed in various parts of the world are very apt to be erroneous. For instance, I was shown a specimen said to have been collected in the Baltic where it was said to have been found by a sailor, but there is not the least probability that it was ever found there. A *Sargassum* is said to have been found on the coast of England, but in his Nereis Britannica Harvey says that he has never seen a British specimen and the figure which he gives in the Nereis was made from an American specimen.

On the Southern side of Cape Cod there is a species of *Sargassum* which is common in many

Fig. 14. *Ascophyllum nodosum* (L) Le Jol. — Part of a drifting plant. Nat. size.

places and is found along the coast as far as Florida and occurs also in Cuba and Bermuda. This species is *Sargassum Filipendula* Ag. and is different from *S. bacciferum*. That is the only species of *Sargassum* found on the coast of the United States from Cape Cod to Florida . . ." "The question, 'where is *Sargassum bacciferum* found growing on the coast of America' is one which cannot be answered directly. Strictly speaking, *S. bacciferum* is found floating and always sterile. It has been assumed by botanists that this floating form, since it does not fruit, must be a pelagic state of some species which fruits where it grows attached. But what is that species and where does it grow? That is rather a matter of speculation than of fact. I have a single specimen collected on the S.E.coast of Florida which appears to be *S. bacciferum* in fruit. The specimen has been seen by J. AGARDH and BORNET who thought it was really *S. bacciferum*. If this is not the only known specimen of *S. bacciferum* in fruit, it is almost the only known specimen. But was it growing attached or floating? The data on that point are not sufficiently definite.

There are several species of *Sargassum* which grow attached in Bermuda and the West Indies. The species which most resembles *S. bacciferum* is the so-called *S. vulgare*, but, although it is possible that these two names represent the attached and the floating stage of a single species, I do not think it can be said that the fact is definitely proved.

On the whole, it may be said that the chances are in favor of the theory that the floating form of *Sargassum* is derived from an attached form growing on the Eastern coast of Florida and the adjacent Antilles rather than in favor of other theories.

As to the Gulf of Mexico, its algal flora is not very well known. So far as known its algal flora is poor compared with that of the Atlantic coast of Florida and the Antilles. I have no specimen of *Sargassum bacciferum* from the Gulf of Mexico in my herbarium but I believe there are specimens in some herbaria. Nevertheless, I believe it to be true that the *S. bacciferum*, if found there at all, is found in a very much less abundance than on the Atlantic coast. . . ."

Since, as I have shown, there is not one but 3 common species of *Sargassum* living and floating in the Sargasso Sea, possibly 4 (with sp. V), it is impossible to identify a single attached coastal form with them all. The future and particularly experimental work must, as has been said, determine to what extent the floating forms can be identified with the attached forms. In this connection let me bring to mind the fact that the Sargasso Sea is no new phenomenon, but one of considerable age, perhaps too, considerable from a geological point of view; therefore it is possible that the drift algae, in any case some of them, may have undergone some change from that type to which they originally belonged. In case viable algae are constantly being derived from the coasts, which I doubt, many of them could of course be identified by cultivation-experiments; it is possible, too, that sexual organs could be developed even though the floating forms have led a vegetative existence during thousands of years, which I believe to be the case.

It has often been said that the variations of habitus of the *Sargassum* plants of the Sargasso Sea are so considerable that their subdivision into well defined species is impossible. It is quite true that, at a first trial, it may be somewhat difficult to classify the forms into distinct species, and in certain, comparatively rare, cases the more experienced scientist may find it an arduous task to identify a sample before him. However, in this respect the conditions are hardly different from those involved by other systematic groups and when we bear in mind that sterile plants are concerned here, living under exceptional conditions, it is not to be wondered that their determination is sometimes laborious.

There is, however, no doubt but that relatively constant characteristics prevail in the types described and that the 8 species enumerated by me are "good species".

In order to facilitate the work of future investigators, I have computed the following key, by

means of which it will be possible to quickly identify a given sample with one of the aforenamed 8 species, I—VIII. Furthermore, the figures and, as far as the species IV—VIII are concerned, the habitat, will be of assistance in the determination.

Key for the determination of drifting *Sargassum* forms.

1	The larger leaves less than 3.5 mm. wide (not including serrations)	- 2
	— — — more than 3.5 mm. wide	- 5
2	Stem without thorns. Leaves with sharply sinuate-serrate edge, without cryptostomes. Bladders medium size, usually less than 5 mm.	- 3
	Stem thorny. Leaves either long, narrowly filiform and bladders large — or leaf midrib decidely serrate	- 4
3	Stem abt. 1 mm. diam. Leaves 2.5 mm. maximum width, generally widest below middle, rather regularly and finely thorny-serrate. Bladders slightly ellipsoid, part of them usually with apical extension; bladder-stalk thin, often longer than bladder	Sp. I
	Stem abt. 2 mm. diam. Width of leaves more than 2.5 mm., generally widest above middle, irregularly, coarsely serrate. Bladders spherical without apical extension; bladder-stalk thick, shorter than diam. of bladders	Sp. II
4	Plant light brownish yellow. Length of leaves less than 3 cm. (leaves sometimes lacking). Bladders numerous, mostly small (often only 2 mm. diam.). Stem usually thickly thorned.	Sp. V
	Plant dark brown, very long and scatteredly branched. Leaves long, narrow linear. Bladders often large, attaining 10 mm.	Sp. VII
5	Stem thorny or warty. Leaves usually with the epizoon *Aglaophenia* — or wide, strongly lobate-fringed	- 6
	Stem without thorns	- 7
6	Leaves serrate, errose-serrate or nearly smooth-edged, often with *Aglaophenia*	- 8
	Leaves lobate-fringed, width above 6 mm., without *Aglaophenia*	Sp. IV
7	Plant mostly dark brown. Leaves usually without hydroids, linguiform, errose edge and asymmetrical base	Sp. VI
	Plant brownish yellow, leaves irregularly serrate	- 9
8	Leaves lanceo-linear, length below 3 cm., sharply serrate. Bladders spherical. Stem spotwise thickly beset with long thorns	Sp. V
	Leaves mostly longer. Bladders often slightly oblong. Usually with *Aglaophenia*. Stem ± spotwise warty-thorny	Sp. III
9	Leaves maximum width 6 mm., acutely cuneate tapering down to a stalk	Sp. II
	Leaves width 6—10 mm. tapering down more rapidly and more unevenly, very short-stalked.	Sp. VIII

6. Experiments with drift-bottles in the Atlantic Ocean.

During the years 1912 and 1913, 535 drift-bottles were thrown out into the Atlantic Ocean from time to time. Ordinary champagne-bottles were used, well-corked and the mouth afterwards dipped in pitch. So much sand was poured into each bottle that when floating just the neck projected above the surface of the water. Every bottle held a communication to the finder, printed in many languages. The finder was requested with promise of a reward to answer the 3 questions on the enclosed post-card; 1) the place of finding; 2) the date of finding; 3) the finders name and address.

Fig. 15 and the list show where the drift-bottles were thrown out and where found. As may be seen the number of bottles thrown out in the localities varied. Most ships received orders to throw out

all the bottles at the same time, while in a single instance a ship was requested to throw out 1 bottle per hour during the entire cruise across the Atlantic Ocean.

Of the 535 drift-bottles thrown out, 31 have been received up to the present time, — or rather 31 postals have been returned to Copenhagen to the Danish Committee for the Study of the Sea.

The conclusions drawn as to the velocities and directions of the currents in the ocean coincide

Fig. 15. Chart of drift-bottles, thrown out in the Atlantic Ocean, and of their probable routes.

with what was known previously from the investigations made by PRINCE ALBERT I OF MONACO and KRÜMMEL. In brief the results are as follows.

355 drift-bottles were thrown out in the area here designated as the Sargasso Sea; of these 7 have been found; outside the Sargasso Sea 180 bottles were thrown out; of these 24 have been found. Relatively speaking, abt. 7 times as many of the latter as of the former have been found; there is a natural explanation of this in the fact that on account of the peculiar conditions of wind and current in the Sargasso Sea, drift-bottles in that area, just like the drift-algae there, have difficulty in coming outside; they continue to drift about until they probably are so overgrown with barnacles or other organisms that they finally sink down to a deeper layer of water, where the pressure of the water crushes them.

Many bottles have drifted great distances, the majority more than 3,500 miles, a single one 9,000

miles. The greater number of the drift-bottles found were washed ashore on the West Indies, having been carried in a westerly direction by the North Equatorial Current. Only a single bottle, one of those thrown out at 39°56′ N., 52°17′ W., was immediately seized by the Gulf Stream and borne in a north-easterly direction to Scotland.

Some bottles were thrown out simultaneously 600 miles W. of Gibraltar; these have all drifted in a southerly direction. After 3 months had elapsed 2 of these bottles were recovered on the Canary Islands; after 14—24 months 9 were recovered in the West Indies; after 29 months 1 bottle was recovered in Bermuda, and finally after 45 months had passed 1 bottle was washed ashore on the western coast of Ireland. The main lines of the route followed by these bottles are beautifully mapped out. The first bottle to reach the Bahamas had drifted about 4,000 miles in 365 days, giving an average velocity of 11.0 miles per diem. The bottle which reached Ireland had required 1354 days to cover the 9,000 mile route giving an average of 6.6 miles per diem. However, under favourable circumstances, this distance can be travelled much more quickly; it is possible too, that the bottle was first found some time after its arrival. Experience has shown that the distance to the Bahamas may be covered in 1 year and the distance from 40° N., 52° W. to Scotland in 280 days (bottle No. 1340, average velocity 10.2 miles per diem). With the help of the Gulf Stream the distance from the Bahamas to 40° N., 52° W. can easily be covered in 65 days. A drift-bottle will thus require less than 2 years to travel from a point W. of Gibraltar to the West Indies and from thence with the Gulf Stream to the British Isles.

Note has been made of the fact that all the bottles thrown out W. of Gibraltar (35° N., 15° W.), and recovered in America have landed on the northern coast of the Antilles and the Bahamas. Not a single one has followed a so southern route as to enter the Caribbean Sea, although other bottles thrown out at other points have done so. This must be due to lesser differences in the direction of the winds at different times. The 3 bottles, No.'s 1326, 137 and 1303, which were recovered in the Gulf of Mexico, off the eastern coast of Yucatan, and near Panama, respectively, and which must of necessity have crossed the Caribbean Sea, were all found in the same year, 1916. It is probable that special wind conditions in 1915, have given the bottles a more southerly route than would otherwise have been the case. At the same time 1 of these 3 bottles proves the untenability of the Prince Albert of Monaco's supposition that drift cannot penetrate into the Gulf of Mexico.

Two drift-bottles reached the coast at so late a date that their routes could not be laid down in my chart. It is noteworthy that these two bottles, thrown out in the Sargasso Sea at 24°45′ N. 51°35′ W. on Oct. 13, 1913, were only recovered in 1922, respectively Jan. 23 on the north shore of Eleuthera (Bahama Isls.) and Febr. 12, south of Gibbs Hill Lighthouse, Bermuda. — Only one bottle, No. 1359, of the 30 thrown out at the same station (mapped without indication of date) has been recovered at an earlier date, i. e. April 1916, also at the Bahama Islands. These drift-bottles give a fair impression of the conditions of wind and current in the Sargasso area being such that drift-material will but rarely, and then only after a long time, be able to escape.

In closing let me add that although such experiments with drift-bottles are of considerable value in understanding the distribution and wanderings of fish-species in the ocean, especially the larvae, yet we must remember that the direction and velocity of the currents measured by the help of drift-bottles only refer to the upper layer of water, where the force and direction of the wind have a far greater influence than on the layers of water which lie deeper below the surface.

List of drift-bottles thrown out and recovered.

No.	Thrown out		Recovered		No. of bottles thrown out	No.	Thrown out		Recovered		No. of bottles thrown out
	Date	Place	Date	Place			Date	Place	Date	Place	
	D. M. Y.		D. M. Y.				D. M. Y.		D. M. Y.		
137	23.1.12	32°32′ N. 39°56′ W.	8.4.16	17°53′ N. 88°00′ W.	50	487	27.4.12	c. 35° N. 15° W.	27.4.13	21°04′ N. 75°35′ W.	50
203	13.2.12	44°13′ N. 15°08′ W.	16.6.12	43°35′ N. 7°18′ W.	1	489	»	»	20.6.13	c. 25°00′ N. 76°20′ W.	»
205	13.2.12	44°04′ N. 15°36′ W.	20.11.12	29°23′ N. 13°29′ W.	1	495	»	»	25.9.14	c. 32°25′ N. 65°00′ W.	»
219	14.2.12	43°08′ N. 17°28′ W.	2.8.12	42°52′ N. 9°15′ W.	1	1303	14.9.13	37°54′ N. 46°47′ W.	21.3.16	9°21′ N. 79°57′ W.	15
304	17.2.12	37°12′ N. 29°07′ W.	1 0.3.12	37°44′ N. 25°40′ W.	1	1309	»	»	5.3.17	18°20′ N. 64°08′ W.	»
316	18.2.12	36°12′ N. 31°19′ W.	20.3.12	36°57′ N. 25°14′ W.	1	1312	»	»	13.2.15	39°50′ N. 31°20′ W.	»
451	27.4.12	c. 35° N. 15° W.	2.1.14	18°06′ N. 67°54′ W.	50	1325	27.9.13	39°56′ N. 52°17′ W.	22.2.18	21°37′ N. 72°12′ W.	29
453	»	»	29.7.12	28°05 N. 15°25′ W.	»	1326	»	»	6.8.16	29°43′ N. 93°02′ W.	»
454	»	»	12.1.14	c. 22°12′ N. 74°13′ W.	»	1334	»	»	2.4.17	25°12′ N. 76°12′ W.	»
458	»	»	5.7.13	18°15′ N. 63°14′ W.	»	1340	»	»	4.7.14	c. 58°01′ N. 7°10′ W.	»
461	»	»	11.4.14	25°25′ N. 76°37′ W.	»	1341	»	»	29.11.16	26°48′ N. 80°03′ W.	»
466	»	»	19.7.12	28°25′ N. 16°20′ W.	»	1356	13.10.13	24°45′ N. 51°35′ W.	23.1.22	25°09′ N. 76°09′ W.	30
472	»	»	12.1.16	54°01′ N. 10°01′ W.	»	1359	»	»	2.4.16	24°00′ N. 74°30′ W.	»
475	»	»	22.12.13	22°43′ N. 74°08′ W.	»	1373	»	»	12.2.22	c. 32°25′ N. 65°00′ W.	»
479	»	»	22.2.14	26°50′ N. 77°20′ W.	»	1379	24.10.13	31°59′ N. 59°52′ W.	29.12.15	25°06′ N. 77°25′ W.	40
484	»	»	20.8.13	21°43′ N. 77°13′ W.	»						

Moreover at the following stations drift-bottles were thrown out, none of which have been recovered.

Thrown out		No. of bottles thrown out
Date	Place	
D. M. Y.		
25.1.12	27°14′ N. 49°59′ W.	50
24.11.13	29°24′ N. 48°08′ W.	20
27.9.13	39°56′ N. 52°17′ W.	1

and finally in the period between 13.2.1912 and 23.2.1912, 250 bottles were thrown out, 1 per hour on the route from 44°23′ N., 15°00′ W. to 27°05′ N., 46°24′ W. Of these, 5 have been recovered, those given in the list as No.'s 203, 205, 219, 304 and 316.

7. A parasitic fungus on Sargassum, hitherto unknown.

In March, 1914, Professor C. H. Ostenfeld collected a quantity of *Sargassum* at a locality lying at 33°21′ N. Lat., 45°20′ W. Long. Two of the plants had conspicuous protuberances, which were scattered along the sides of the stems and partly on the bladders as well. These protuberances varied in size; they were sometimes as large as the head of a pin, sometimes $^1/_2$—1 cm. across, irregularly rounded and knobby (Fig. 16). The knobby surface of the tumors was due to tiny peritecia-like loculi, sometimes placed close together in a continuous stroma, lending a black colour to the tumor, sometimes more scattered, the stroma not being continuous but divided into several minor stromata containing only a single or but few loculi, — and in this case the pale tissue of the host was visible between the small partial stromata.

A further investigation revealed the fact that the parasitic organism was a well-developed Ascomycetous fungus, belonging to the Dothideales. Its clypeus-like stromata refer it to the *Phyllachoraceae*[1] (Fig. 17). The curious substratum makes impossible a direct parallel between the position of this fungus in the tissue and that of the *Phyllachoraceae*, which are parasites on phanerogamous plants. However both Prof. Ferdinandsen and I consider that it is correct to refer the fungus to the genus *Phyllachorella* Syd.

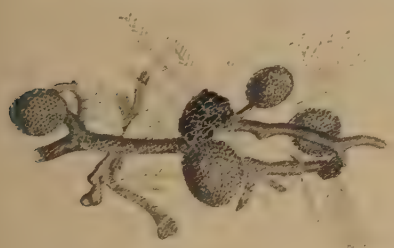

Fig. 16. *Phyllachorella oceanica* nov. spec. Ferd. et Wge. — Part of a *Sargassum*-plant (*Sarg. III*) with the fungus. — × $^4/_3$.

The fungus was found present on 2 *Sargassum*-species, namely on those referred to in this paper as *Sarg. II* and *Sarg. III*. The stromata of the fungus were usually overgrown with epizoa.

A diagnosis in Latin follows.[2]

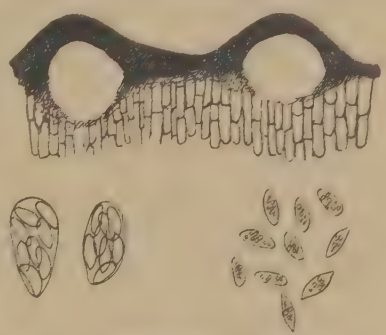

Fig. 17. *Phyllachorella oceanica* nov. spec. Ferd. et Wge. — Part of stroma with 2 loculi (above) — × $^{20}/_1$. Asci and spores (below). — × $^{200}/_1$.

Phyllachorella oceanica Ferdinandsen et Winge sp. n. Stromatibus matrici tumefactae incidentibus, strato corticali innatis, nunc unilocularibus, punctiformibus, nunc crustas moriformi-tuberculatas, usque ad 1 cm. latas formantibus, atris. Loculis in tuberculo singulo stromatis pluribus immersis, fere globosis, 500—800 μ diam., superne strato nigrefacto crasso, quod saepius inter loculos plus minusve prorepit eosque interdum cingit, tectis. Stratis subjacentibus matricis hyphis fungi intertextis. Ascis late ellipsoideis, plerumque 55—77 $\mu \asymp$ 24—32 μ, sessilibus; paraphysibus nullis. Sporis octonis, disticis, aseptatis, hyalinis, multiguttulatis, plurimis 20—30 $\mu \asymp$ 10—13 μ, forma (? secundum aetatem) valde varia; saepius ellipsoideis utrinque late rotundatis vel truncatis, rarius fusiformibus, apicula recta subcurvatave praeditis.

Species habitatione praedistincta, oceanica, caules nec non vesicas duarum specierum *Sargassi*, in hoc opusculo *Sarg. II* et *Sarg. III* denominatorum, infestans, Lat. 33°21′ N., Long. 45°20′ W. mense Martio 1914 a cl. C. H. Ostenfeld lecta. — Stromata saepe *Aglaophenia latecarinata* et *Membranipora tuberculata* obsessa.

[1] F. Theiszen und H. Sydow: Die *Dothideales*, Berlin, 1915.

[2] A description of the new fungus has been published by Prof. Ferdinandsen and the writer in "Mycologia", March 1920.

8. Summary.

Opinions have differed as to the boundaries of the Sargasso Sea, which until now have been incorrectly marked out on the charts of the ocean. Nor have the various floating *Sargassum*-forms been clearly understood nor kept distinct.

The investigations published here have determined the location of the Sargasso Sea; and its extent, E. of 60° W. Long., has been marked on the chart with necessary certainty. While the N. boundary moves further to the north during the summer, and further to the south during the winter, depending on the direction of the prevailing winds, the S. boundary remains rather stationary.

The vegetation of the Sargasso Sea consists of 3 common species of *Sargassum* spread over the whole area (*Sargassum* I—III); they live and propagate vegetatively year after year and have a distinct optimum period of growth in late summer. Besides, 5 less common species (*Sargassum* IV—VIII) are found, but generally only in the western regions, the Gulf Stream territory; they are supposed to be identical with existing coastal forms. Of these 5 species, the lifetime of which very likely does not extend over more than a few months as a rule, *Sargassum* V possesses such active power of vegetative propagation that it has spread over a wider area than the 4 others. — The 8 species concerned have been denominated *Sargassum* I—VIII in this paper and are represented in Fig. 3 to 13. Frequently *Ascophyllum* is also found drifting in the Gulf Stream.

It is uncertain whether *Sargassum* I—III, the three inhabitants proper of the Sargasso Sea, belong to existing coastal forms; no individuals of these species have been found that give evidence of coastal origin: they are all devoid of basal disc and fructification shoots.

Eventual identification of the floating *Sargassum*-species I—III is only possible by experimental research, by means of which the sexual organs can be made to develop and the original "coastal habitus" of the plants be reattained.

Sargassum requires a temperature above 18° C. in order to thrive, and for that reason, among others, cannot reach the coasts of Europe nor the Mediterranean alive as drift.

Of 355 drift-bottles thrown out in the Sargasso Sea, only 7 (1.97 %) have been reported recovered. Of 180 thrown out outside the boundaries of the Sargasso Sea 24 (13.33 %) have been recovered. Experiments with drift-bottles verify in the main the results hitherto reached in similar experiments concerning the direction and velocity of currents in the Atlantic Ocean.

A hitherto unknown Ascomycetous parasite on *Sargassum*, *Phyllachorella oceanica* Ferd. and Wge. has been described and figured.

REPORT ON THE DANISH OCEANOGRAPHICAL EXPEDITIONS 1908—10
TO THE MEDITERRANEAN AND ADJACENT SEAS
Vol. III. Miscellaneous Papers.

3.

On the quantity of Macroplankton in the Mediterranean and the Atlantic.

By

P. Jespersen.

Published December 15, 1923.

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I. INTRODUCTION.

The Danish Commission for the Study of the Sea has during the past twenty years made a series of investigation cruises in the Atlantic and the Mediterranean. By far the greater part of the work was carried out with implements for pelagic fishery, and the volume of plankton brought up by the various hauls was in many cases calculated by a simple method of determining the cubic capacity. The journals contain a considerable amount of data bearing on the quantity of plankton fished in the Atlantic and the Mediterranean; and I have therefore thought it worth while to set out the results of these observations, in order to give a general idea as to the quantity of plankton found in various parts of these seas. It is these volume determinations of macroplankton which form the basis of the present work.

The Danish investigation cruises in the Atlantic and the Mediterranean, all of which were carried out under the leadership of Dr. Johs. Schmidt, may be divided as follows:

1. Cruises with the research steamer "Thor" round the Færoes and Iceland and along the west coast of Ireland down to the Bay of Biscay, during the years 1903—1908.

2. Two cruises to the Mediterranean with the "Thor" in the winter of 1908—09 and summer of 1910.

3. Three transatlantic cruises, viz:

1913, cruise of the schooner "Margrethe" from the Færoes to the Azores and cruise via Newfoundland and the Bermudas to the West Indies,

1920, cruise of the schooner "Dana" across the Atlantic from Gibraltar to the West Indies and in the western part of the North Atlantic, and finally,

1921—22 the great cruise of the research steamer "Dana", from the western portion of the Mediterranean across the Atlantic to a point off the coast of French Guiana, thereafter investigations in West Indian waters, with a short trip into the Pacific and further in the western part of the North Atlantic, with a final section from Norfolk (U. S. A.) out into the Sargasso Sea and via the Azores to the Channel.

On these cruises, a number of different implements were used, fishing pelagically, but as they were not all employed to the same extent, the data here considered are restricted to those for one or two implements most frequently used.

I think it right to point out that the volume determinations here given only touch on the purely quantitative side of the question and thus only give the volume of the total quantity of plankton brought up. The composition of the plankton taken is, of course, highly variable as between one place and another; in the present work however, the qualitative aspect of the question has been disregarded, save for some general remarks as to the most dominant forms.

One of the implements more particularly used on these cruises was a 2 metre stramin-net[1] — i. e. a bag-shaped net of "stramin", stretched on an iron ring abt. 200 cm. diameter. On the cruises in the Atlantic from 1903—08, and the two Mediterranean cruises of 1908—09 and 1910, on the other hand, the Petersen young-fish trawl was used[2]. Both these implements being made of stramin, and the mouth of the young-fish trawl being likewise 200 cm. diameter, the two would probably have about the same fishing

[1] "stramin" is a coarse canvas made of hemp, having abt. 20 threads to 3 cm.

[2] See Vol. I, Introduction to the present work, p. 8.

capacity. Implements made of stramin will naturally, from their relatively large mesh, not be able to collect the smaller plankton organisms in any great quantity, and practically speaking, we may say that these implements only to a slight degree bring up phytoplankton and protozoa, the hauls being predominantly composed of organisms which may be classed among the macro- and mesoplankton. Obviously, there can be no question of any absolute sorting out of the organisms in this respect, but in the main, it must be said that these implements are solely designed to bring up the relatively large plankton organisms. For greater convenience, I have in the present work used only the term macroplankton, though as a matter of fact, the expression must here be understood as comprising organisms generally ascribed both to the macro- and the mesoplankton. In addition to the above-mentioned young-fish trawl, I have also included in the following a number of volume determinations from material collected in 1905 and 1906 with a larger young-fish trawl having an opening diameter of 330 cm.

The method of measuring the volume was as a rule as follows: The material was poured out into a sieve, the sides of which were marked off into divisions at measured intervals, and the cubic capacity then calculated when the water had run off. Determinations of volume by this method must of course necessarily be somewhat rough, and the figures accordingly make no claim to great precision, merely serving to give a general idea as to the distribution of the quantities of plankton.

It should further be noted that the implements used were "open" nets, that is to say, that the net itself, after having been lowered down and towed at a certain length of wire, was hauled in while still open. Naturally, then, the net would actually fish while being paid out and hauled in again. This fact alone renders it impossible to use the material for determinations of volume with any high degree of accuracy. As, however, all the calculations have been worked out into hauls per hour, and the hauls themselves often extended over several hours, the quantity taken during process of paying out and hauling in would doubtless in most cases be altogether minimal in proportion to the total amount of plankton.

We have in all about 700 plankton determinations from hauls made with the 2 metre stramin-net and the 2 metre young-fish trawl, partly from the Mediterranean and partly from the Atlantic, and I have arranged them in order of the approximate depths at which the nets were towed. As the pelagic fishery was carried out almost exclusively at night, only night hauls have been here included. In the case of each separate haul, the volume of plankton brought up has been transposed so that all the figures given in the tables and charts indicate calculated volume per one hour's haul. After marking off these volume determinations on the charts, I have calculated the average volume within an area of 10 degrees of longitude and 10 degrees of latitude. We thus obtain a series of figures which are more or less comparable, and these figures show the average volume im ccm. per hour. I am perfectly aware that this method of proceeding is open to many objections, as the geographical conditions are thus disregarded, but as it would be impossible to include all the material in the charts, and our object is only to give the roughest outlines of the quantitative distribution, I consider it justifiable to use this method for the purpose of showing up the result.

With regard to the depth at which the various hauls were made, the following should be noted. The absolute depth at which the nets were towed is as a rule unknown, only the length of wire out being generally recorded, so that there can only be a question of relative depth. The lengths of wire used in the great majority of cases are as follows: 25—65 metres, 100 m., 300 m., and 600 m. wire. All hauls made with any one of these lengths of wire will thus be more or less comparable, presuming that the same length of wire will always indicate approximately the same depth absolute; generally taken as amounting to about one half to two-thirds the length of wire out. The depth at which the nets fish is of course primarily dependent upon the rate at which the vessel moves, but as far as possible, towing is always done at the same rate of speed, viz. abt. two knots.

II. QUANTITY OF MACROPLANKTON IN THE UPPER WATER LAYERS (25—65 m. w.).

From the Mediterranean and the northern parts of the Atlantic, we have only volume determinations from the upper water layers. We will therefore begin by considering the quantity of plankton in these water layers (Fig. 1), in order to obtain a survey of the whole of the area investigated, from which we have

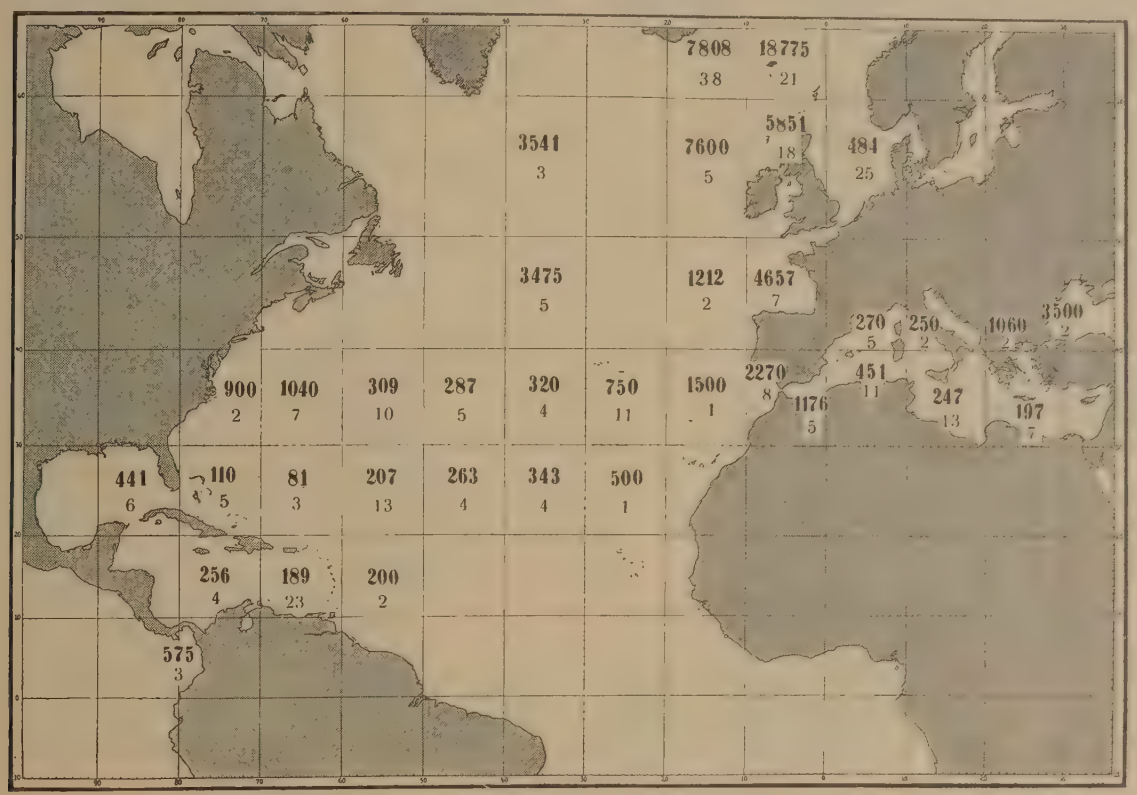

Fig. 1. Average volume (in ccm.) of macroplankton in the upper water layers (25—65 metres wire).

any data as to quantity of macroplankton. Hauls in the upper water layers comprise all hauls made with lengths of wire from 25 to 65 metres. The figures within each area of 10 degrees longitude and latitude indicate, as throughout in this report, the number of ccm. plankton taken per hour in each such area. It should be noted, however, that in the case of the Straits of Gibraltar, I have calculated the average volume for the Bay of Cadiz and the Alboran Sea respectively; the average volumes for the Sea of Marmora and the Black Sea are likewise noted separately. In all charts, the figures in smal type indicate no. of hauls made within the various areas.

With regard to the Mediterranean, it should be noted that volume determinations are here only given from the summer cruise, as there seems, at any rate, in certain parts of the Mediterranean, to be considerably less plankton present in winter than in summer. This however, is a point to which I shall refer more in detail under the special heading of Mediterranean material. In the central parts of the Atlantic, there does not appear to be any discernible difference in the quantity of macroplankton present at different

seasons, and in the case of the northern Atlantic waters, we have no data concerning the quantity of plankton in winter.

Let us first consider the Atlantic. Between 20° and 30° N. lat., in the western Atlantic, we find a minimum in the quantity of plankton which is particularly striking. Between 60° and 70° W. long. the average taken was only 81 ccm. per hour. Starting from this minimum, and considering the average figures between 20° and 30° N. lat., we find that the quantity of plankton is considerably greater in the Gulf of Mexico, and that the quantity rises gradually in an easterly direction, showing the following figures between the degrees of latitude noted: 207, 263, 343 and 500 ccm. In the Caribbean, however, the quantity of

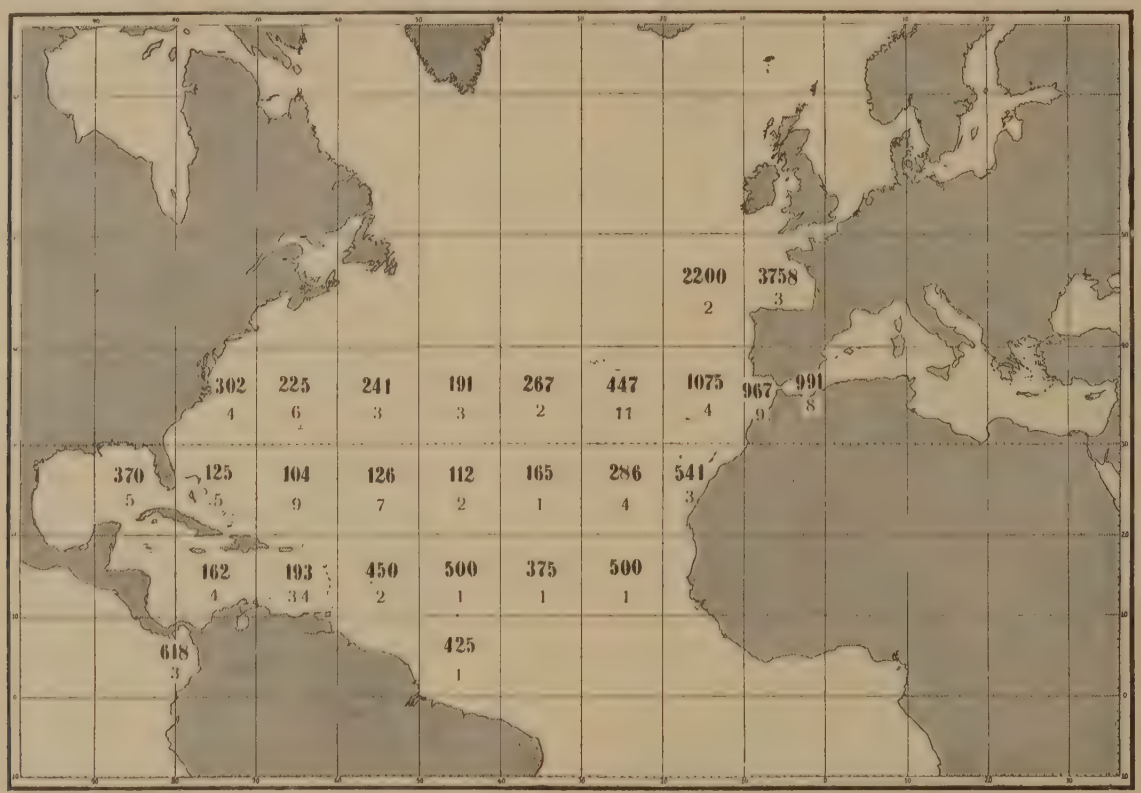

Fig. 2. Average volume of macroplankton from hauls with 100 metres wire (2 metre stramin-net).

plankton is also relatively small. Some few hauls made in the Bay of Panama show a considerably richer quantity of plankton than in the Caribbean. Proceeding then to consider the average volumes between 30° and 40° N. lat. it will be seen that the quantity of plankton is smallest between 30° and 60° W. long. and that the average volume within this area shows but relatively slight variation. Both between 20° and 30° N. lat., and between 30° and 40° N., we have thus a minimum in those parts of the Atlantic generally termed the Sargasso Sea. Between 30° and 40° N., there is likewise an increase in the quantity of plankton both towards the east and towards the west. The rise to the westward is somewhat abrupt, the volume west of the Bermudas increasing to abt. 1 litre per hour. Moving eastwards, we find abt. $^3/_4$ litre round the plateau of the Azores, and in the Bay of Cadiz, the volume rises to abt. $2^1/_4$ litres per hour. In other words, the average quantity of macroplankton collected in the Bay of Cadiz per hour's haul is seven or eight times that so taken in the central portions of the Atlantic between 30° and 40° N. lat.

Passing in from the Bay of Cadiz through the Straits of Gibraltar, we at once notice that the plankton in the Alboran sea is already considerably less in quantity than in the Bay of Cadiz, and that

the volume decreases quite appreciably inwards through the Mediterranean, giving the smallest quantities of plankton in the eastern part of the Mediterranean. With regard to the Sea of Marmora and the Black Sea, we have only few hauls made here in these water layers, but the results show a very considerable volume. Average in the Marmora abt. 1 litre, and in the Black Sea 3.5 litres per hour. The great quantity of plankton in these waters is due more particularly to a very rich occurrence of various Medusæ.

Turning then to the Atlantic north of 40° N., we find everywhere an average of over 1 litre, and as a rule a volume of several litres. Unfortunately, our material is almost entirely restricted to the eastern part of this area, with hardly any information as to the central parts of the Atlantic in these northern

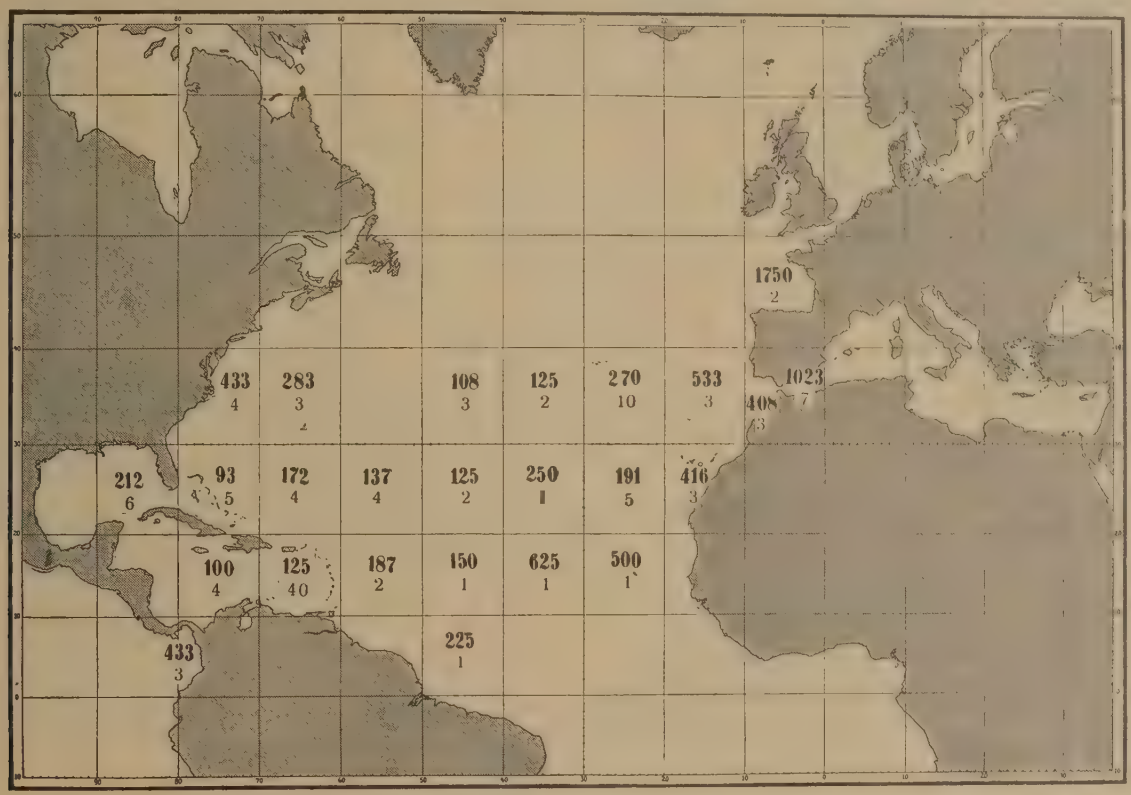

Fig. 3. Average volume of macroplankton from hauls with 300 metres wire (2 metre stramin-net).

latitudes. The few hauls made between 30° and 40° W. long., however, show a considerable volume, the average taken being abt. 3½ litres per hour. In the Bay of Biscay, the average is abt. 4½ litres, and west of Ireland and between Scotland and Iceland, 7—8 litres. Between the Shetland Islands and the Færoes, and in the waters round these islands, we get the enormous average of 18.7 litres per hour, due more particularly to huge quantities of Salps at certain stations. This figure is based on 21 hauls, but as the variation in the quantity of plankton is extremely great within this area, the calculated average figure tells us very little. Altogether, the average volume is not the most suitable term whereby to express the quantity in areas so rich in plankton as these, as the amount of plankton is extremely variable. The maximal quantities within each of this areas will therefore presumably give a more correct idea of the actual conditions, and I have therefore, at the close of this work (p. 15) shown the range of variation of the volume within the various areas.

From the North Sea, we have a series of volume determinations; the average of all volume determinations from the North Sea (34 hauls) comes to 1282 ccm. per hour. The quantity of plankton in

the northwestern part of the North Sea (W. of Greenwich) is, from the observations available, much greater than in the other parts of the North Sea. The range of variation for the volume in the North Sea W. of Greenwich for instance is 150—20,000 ccm. and for the North Sea E. of Greenwich, 50—1000 ccm. The average for the latter area, based on 25 hauls, amounts to only 484 ccm. per hour.

The available material, however, is not sufficient to afford any reliable view of the distribution of the quantity of macroplankton in the North Sea, and the calculated averages are only quoted as illustrating the difference apparently existing between the quantities of macroplankton in the different areas.

Fig. 4. Average volume of macroplankton from hauls with 600 metres wire (2 metre stramin-net S. of the dotted line, 1½ metre stramin-net N. of the line).

III. QUANTITY OF MACROPLANKTON IN THE DEEPER WATER LAYERS (100, 300 AND 600 m. w.).

Data concerning the quantity of plankton in the deeper water layers are available in the present material for the two last Atlantic cruises, but that is practically all. These two cruises are those of the schooner "Dana" in 1920 and the research steamer "Dana" in 1921—22. The information is thus almost exclusively from the North Atlantic S. of 40° N., the western Mediterranean (Alboran Sea) and the Caribbean.

The figs. 2, 3 and 4 show the average quantities of plankton noted for depths answering to 100, 300, and 600 metres of wire. As in Fig. 1, the figures indicate average volume (in ccm.) taken per hour within areas of ten degrees of longitude and ten of latitude.

Fig. 2 shows the average volume from hauls with 100 m. w. In agreement with the volume determinations from the upper water layers, (25—65 m. w.) we find also at this depth a pronounced

minimum in the quantity of plankton in the Sargasso Sea, and in the main, the distribution of the plankton quantitatively, throughout such areas as our information covers, corresponds exactly to what we find in the upper water layers. And further consideration of the volume determinations at depths answering to 300 and 600 m. w. (figs. 3 and 4) will show that the volume as a whole decreases with increasing depth, but that the distribution of the quantity of plankton in the various areas shows the same features in all essentials. The smallest quantity of plankton is always found in the Sargasso Sea, the volume being considerably greater in the surrounding waters. At depths with 100 m. w. (fig. 2) and 300 m. w. (fig. 3) a 2 metre stramin-net was invariably used, whereas with 600 m. w. (fig. 4) in addition to the 2 metre stramin-net a somewhat smaller net was also used, the $1^1/_2$ metre stramin-net (diameter of the net at its mouth $1^1/_2$ metres). In the chart given, all hauls with the 2 metre stramin-net lie south of the dotted line, and hauls with $1^1/_2$ metre stramin-net north of that line.

IV. VOLUME DETERMINATIONS FROM A SERIES OF STATIONS ACROSS THE ATLANTIC.

In order further to illustrate the distribution of the quantity of plankton across the Atlantic, we will proceed to examine more closely the fluctuations in volume at a series of stations on the cruise of the research steamer "Dana" in 1922. On this cruise, a series of stations were taken from Norfolk (U. S. A.) to the Bermudas and thence south-eastward to abt. 27° N. 50° W., and on from there in a straight line via the Azores to the Channel. On this section, a series of hauls was made with lengths of wire from 25—50 metres, 100 m., 300 m. and 600 m., and the volume of the material brought up was measured. The hauls at the three upper depths were all made with the 2 metre stramin-net, all those with 600 metres of wire being made with $1^1/_2$ metre stramin-net. The graph fig. 5 shows the volume noted for the separate hauls, the figures on the ordinate indicating volume in ccm., and those on the abscissa the degrees of longitude across the Atlantic. Volume for each haul is calculated per hour.

It is most distinctly apparent from the graph that the quantity of plankton in the central parts of the Atlantic is relatively very small at all depths from which volume determinations are available. It will be noted that the quantity of macroplankton is quite considerable in the western part of the area investigated, i. e. the quantity of plankton west of the Bermudas, which lie at abt. 65° W., is considerably greater than in the Sargasso Sea. Round the Azores, at about 25° W. the volume increases very greatly, and outside the Channel, we get the great quantities of 5000 ccm. and 6000 ccm. at 25—50 and 100 m. w. respectively. The dominant forms here were Euphausids and Hyperids.

The enormous variation in the quantity of plankton in the different areas of the Atlantic is particularly conspicuous in this section, and it should further be borne in mind that the graph here shown does not give the right proportion between the very great quantities outside the Channel and the remaining material. In reality, the very large quantities should be set off at about twice the distance from the abscissa to show the proper state of things.

On the whole, the curves for the various depths show a quantity of plankton greatest as a rule in the upper water layers, but we cannot, from the material available, point out any definite depth at which the quantity of plankton is greatest. In most cases, the greatest volume is found at a depth of 25—50 or 100 m. w., gradually decreasing thence at 300 and 600 m. w.

Comparing the quantities from the stations N. of the Azores and in the Sargasso Sea, it will be seen that the upper water layers (25—50 and 100 m. w.) in the former waters gave, in point of volume,

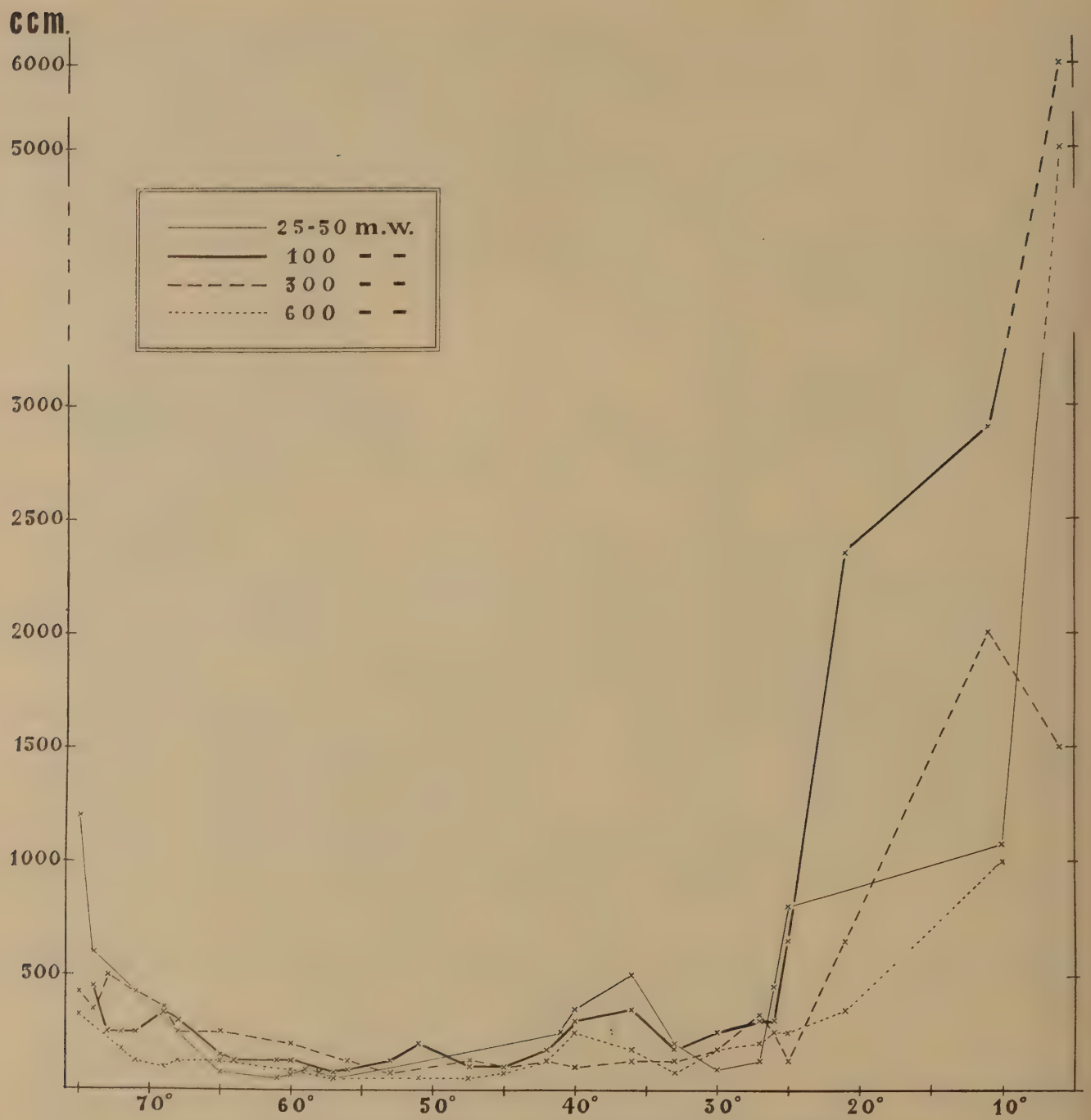

Fig. 5. Volume of macroplankton at a series of stations across the Atlantic.

20—30 times as much plankton per hour as the Sargasso Sea. As regards the deeper water layers, (300—600 m. w.) the difference is apparently not so great, but on the whole we may say that in these depths, the volume taken was 5—10 times as great outside the Channel as in the Sargasso Sea.

V. QUANTITY OF MACROPLANKTON OVER DIFFERENT DEPTHS OF SEA.

In the years 1905 and 1906, as previously mentioned, a particularly large young-fish trawl was used in the area west of Ireland and down into the Bay of Biscay. This young-fish trawl had an opening diameter of 330 ccm. and we have volume determinations from hauls with 100—300 m. w. The volume determinations from these investigations cannot, of course, be directly compared with the results of hauls made with the smaller young-fish trawl, but it is nevertheless interesting to consider the result of the work with this net. The implement was used only on the slope out towards the deep Atlantic on the range from Ireland to the inner part of the Bay of Biscay. A calculation of the average volume of plankton taken over different depths reveals the interesting feature that the quantity of plankton increases markedly out towards the deeper water. The figures below show the average volume of plankton per hour within the various depths, the figures in parentheses indicating the no. of hauls from which the average was calculated.

< 200	metres:	2.190	litres	(6)
200—1000	—	4.780	—	(4)
1000—2000	—	15.880	—	(15)
> 2000	—	29.285	—	(7)

It is thus evident that the quantity of plankton increases greatly from the shallower water out towards the great depths. But what then are the organisms more especially accounting for the great volumes noted above deep water? On going through the journals we find that they are predominantly Medusæ and Salpæ, which here appear in such enormous quantities and thus produce the very great volume noted.

VI. QUANTITY OF MACROPLANKTON IN THE MEDITERRANEAN.

From the Mediterranean, we have investigations from the cruises of the "Thor" in the years 1908—09 and 1910. The first cruise was made during winter, and the second in summer. As there appears to be a very conspicuous difference in the quantity of plankton in certain parts of the Mediterranean between the two cruises, the results of each will be taken separately. The data available comprise only hauls from the upper water layers (25—65 m. w).

The two charts given below show the average quantity of plankton per hour calculated in the same manner as in the previous charts. Owing to the relatively smaller extent of the Mediterranean, however, the average figures here are calculated within areas of 5 degrees of longitude and 5 of latitude. Fig. 6 shows the result for the winter cruise, and fig. 7 that for the summer cruise. It will be noted that in both charts, the volume decreases markedly from west to east. In the Alboran Sea, the volume is far greater than in the remaining parts of the Mediterranean. Between 0° and 10° E. the quantity of plankton is considerably smaller, and the separate data show no great variation, but east of 10° E., the quantity of plankton becomes considerably smaller, and decreases more or less evenly towards the east. These remarks apply both to winter and summer, but on comparing the figures for winter and summer east of 10° E., it will

be noted that the quantity of plankton is very considerably smaller in winter that in summer. Unfortunately, we have no investigations from the eastern Mediterranean during winter, but judging from the avail-

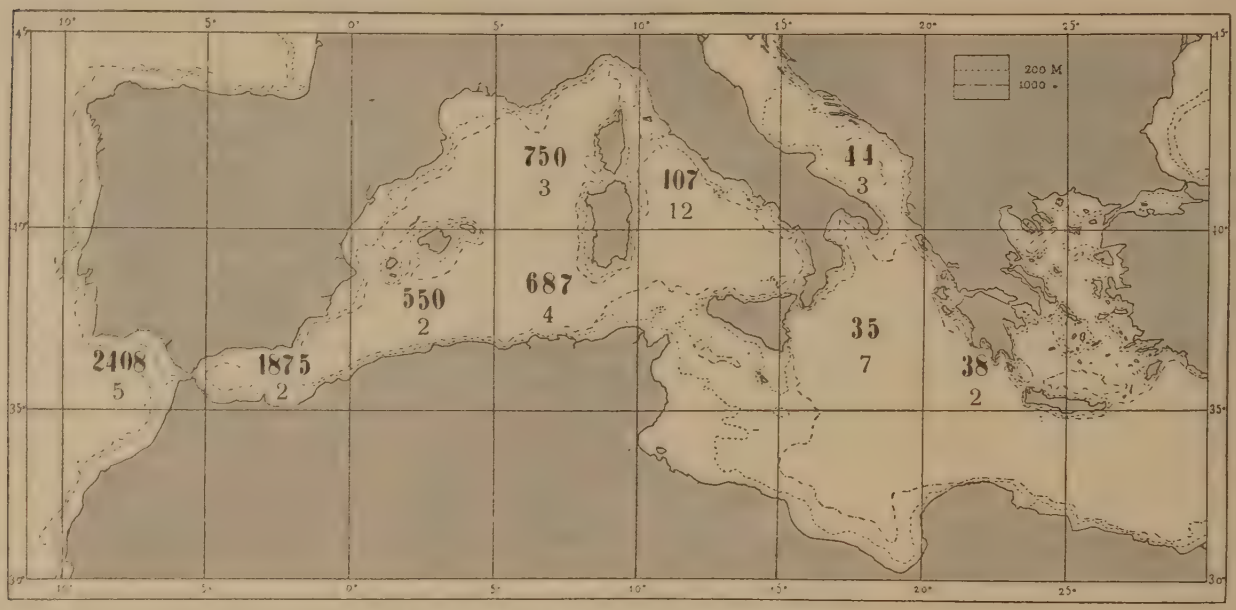

Fig. 6. Quantity of Macroplankton Winter 1908—09.

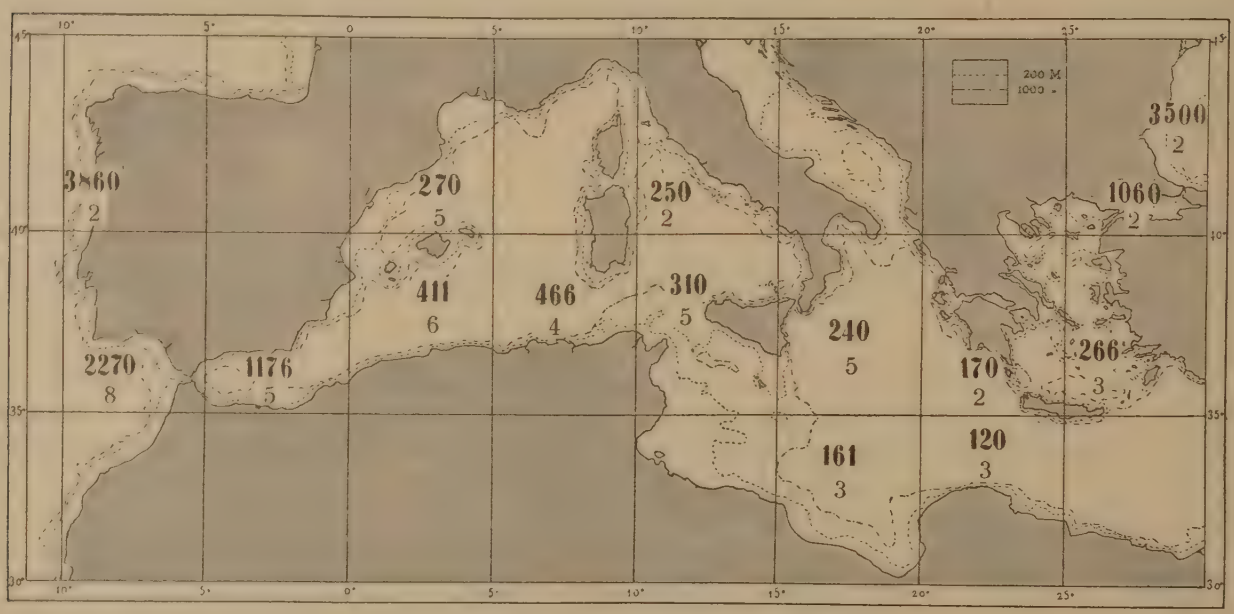

Fig. 7. Quantity of Macroplankton Summer 1910.

able material there seems nevertheless some likelihood that the quantity of plankton throughout the whole of the eastern Mediterranean is smaller in winter than in summer. The average figures are best represented within 15° and 20° E., and the volume here is 6—7 times as great in summer as in winter.

The very great volumes in the Marmora and the Black Sea during summer are more particularly due to a very large quantitative occurrence of various Medusæ.

The existing variation in total quantity of plankton in winter and summer in certain parts of the Mediterranean agrees with the results of investigations in more northerly waters. In the case of the Mediterranean, however, such variation has, as far as I am aware, only previously been shown near the coasts (see for instance STEUER 1910 and HENSEN 1911). For the northern waters, I will here merely refer to the comprehensive investigations from the Irish Sea and the west coast of Scotland, which have been carried out through a considerable period of years (HERDMAN, SCOTT and LEWIS 1908—1921; HERDMAN and RIDDELL 1911). In the months from November—February inclusive, the total quantity of plankton is very small in comparison with the remaining months of the year, which is especially due to the abundant growth of phytoplankton in spring and autumn. Investigation of the quantitative variation of the zooplankton shows in the main something similar. The variation in the total quantity of Copepods for the various months of the year shows, for instance, a pronounced minimum from November to March inclusive.

Fig. 8. Average number of *Meganyctiphanes norvegica* per hour (25—300 m. w.) ● positive stations, ○ negative stations.

For the Mediterranean, I have further had access to some material affording a view of the quantitative distribution of a single plankton organism. VILH. EGE, M. Sc., of the Carlsberg Laboratory, compiled some years back variational statistics with material of *Meganyctiphanes norvegica* M. Sars, from the Mediterranean cruises of the "Thor". The mentioned investigation did not give any clear result as to the variation in point of size, but did, on the other hand, give some very interesting information as to the distribution of this Euphausid in the Mediterranean. I beg to offer my best thanks to Mr. EGE for permission to make use of this material.

Meganyctiphanes norvegica plays a very essential part in the marine plankton in certain parts of the Mediterranean. The chart given above shows the average no. of specimens of *Meganyctiphanes* per one hour's haul at depths from 25 to 300 m. w. Where the material taken was very large, the number of specimens is estimated from the volume. It will be noted that the average value is very low from the Straits of Gibraltar to 5° E. while the species occurs in very great quantities within 5° and 10° E.

Between 5° and 10° E., we get average values of 111 and 446 specimens for S. and N. of 40° N. lat. respectively. Between 10° and 15° E., the means are 37 and 24 and between 15° and 20° E. the mean is 27, while the Adriatic shows a calculated mean value of 88 specimens. East of 20° E., we have a few specimens in the Ægean and the Marmora, in the latter area, 10 specimens per hour were taken. The distri-

bution of positive and negative stations, in connection with the quantities, shows very distinctly that *Meganyctiphanes* is a plankton form occurring in greatest numbers in the central portions of the Mediterranean and evidently not found in the eastern part of that sea.

This result is based solely on material from the Mediterranean cruises of the "Thor", but as *Meganyctiphanes* occurred in considerable quantities during the stay of the "Dana" in the Straits of Gibraltar in October 1921, it is evident that the species can at certain seasons or years be numerous in the Alboran Sea.

Meganyctiphanes norvegica is an instance of a plancton crustacean playing a very great part in certain portions of the Mediterranean while occurring only very sparsely in the eastern Mediterranean waters. Its occurrence, at any rate in great parts of the Mediterranean, considerably affects the total quantity of macroplankton.

VII. GENERAL REMARKS ON THE QUANTITY OF PLANKTON.

The available material of volume determinations from the Atlantic shows on the whole that the Sargasso Sea is relatively very poor in macro- and mesoplankton compared with the adjacent areas of sea. In the Atlantic north of the Azores, for instance, the quantity of macroplankton taken per hour in the upper water layers is at least 20 times that in the central waters of the Sargasso Sea. In the Mediterranean, the quantity of plankton decreases markedly in the eastern part, and the quantity of macroplankton here, especially in winter, is almost as small as that in the Sargasso Sea.

As the present volume determinations were not made with any high degree of accuracy, the material only serves to give a very rough idea as to the quantitative distribution of the macroplankton. Owing to the relatively coarse mesh of the nets used, a partial sorting out of the material took place, so that at any rate for the most part, only the larger organisms were brought up. Phytoplankton and protozoa must in all essentials be regarded as excluded from the hauls, but the nature of the implements here used will of itself preclude any direct comparison of these volume determinations with those of previous investigations. Despite various disabilities attaching to the present material, however, it seems nevertheless to afford something of a rough idea as to the quantitative distribution of the macroplankton in certain parts of the Atlantic and the Mediterranean.

We find in extant literature volume determinations of plankton from various waters, but only in very few cases is any information given as to the open Atlantic. The volume determinations best suited for purposes of comparison with the present material are the results of the German Plankton Expedition of 1889. The results are, it is true, not directly comparable, as the Plankton Expedition used close-meshed nets making only vertical hauls, but since the investigations were carried out partly in the same waters, it is of interest to glance at the volume determinations from this expedition (Hensen 1890, 1911, Schütt 1892). As the German Plankton Expedition used nets of far finer mesh than the Danish expeditions, it is obvious that the Plankton Expedition would collect microplankton (phytoplankton and protozoa) to a far greater degree, and the plankton obtained would from this fact alone have an altogether different composition. But despite the difference in implements and method of fishing, between the German and the Danish expeditions, we find nevertheless in the main that the relative quantities of plankton correspond to a certain extent within the areas investigated. In and near the tropics, the quantity of plankton was relatively small. The average volume in these waters was about 8 times as small as in the northern waters, and the plankton in the Sargasso Sea was quite exceptionally poor in quantity. The fluctuations in the quantity of plankton in the Sargasso Sea were relatively inconsiderable, and the volume was on an average

15 times poorer than in the northern waters and 10 times poorer than on the other parts of the route of the Plankton Expedition.

From the above brief summary it will be seen that the results of the Plankton Expedition agree in the main well enough with the volume determinations made on the Danish expeditions in the Atlantic.

Besides the results of the Plankton Expedition, I will briefly mention Prof. LOHMANN's investigations on the quantity of centrifuge-plankton in the North Atlantic (LOHMANN 1912, 1917, 1922). From the Sargasso Sea proper there are no investigations, as the route of the vessel only touched the outer, eastern margin of this area, but some average values from various parts of the Atlantic will nevertheless be of interest in this connection. In the tropics, an average of 2500 organisms per litre of water was found, whereas the cold water north and south of the tropics was more than 8 times richer. Here, one litre gave on an average 21000 organisms. I give below, from LOHMANN 1917, a table showing average no. of phytoplankton organisms within the different degrees of latitude in the northern Atlantic.

North Latitude.

Depth	50—40°	40—30°	30—20°	20—10°	10—0°
0 m.....	20.000	7.000	1.800	2.000	3.000
50 -	20.000	5.000	1.600	1.500	2.000
100 -	3.000	2.000	1.000	700	400
200 -	3.000	200	200	80	100
400 -	2.500	100	30	5	60
0—400 m.....	6.000	2.000	600	500	600

Also the purely microscopical plankton then, shows far smaller relative quantities in the warmer parts of the north Atlantic than in more northerly areas, and this feature would thus seem to apply to all the three generally recognised categories of plankton: micro-, meso- and macroplankton.

VIII. SURVEY OF THE VARIATION IN QUANTITY OF MACROPLANKTON.

In the lists given below will be found the smallest and the greatest volume in ccm. for the different areas. In accordance with the mean values marked on the charts, the areas in the Atlantic embrace an extent of 10 degrees of latitude and 10 of longitude (figs. 1—4) while in the Mediterranean, they are based on 5 degrees of latitude and longitude (figs. 6—7). The number of hauls within the different areas and the calculated mean values can be directly seen from the respective charts.

Atlantic 25—65 m. w. (fig. 1).

	90° W.	80°	70°	60°	50°	40°	30°	20°	10°	0°
60°—70° N..	.....	.....	.....	.....	.....	.....	.....	100—20.000	75—200.000	
50°—60° - ..	.....	.....	.....	.....	.....	125—10.000	.....	4.000—20.000	50—240.000	
40°—50° - ..	.....	.....	.....	.....	.....	125—15.000	.....	1.075— 1.350	100— 20.000	
30°—40° - ..	.....	600—1.200	50—5.000	80—562	187—375	200— 500	75—5.625	1.500	.....	
20°—30° - ..	200—875	35— 175	60— 125	50—312	125—312	165— 500	500	.....	.....	
10°—20° - ..	.....	175— 300	75— 600	125—275	.....	.....	.....	.....	.....	
0°—10° - ..	.....	350— 750	.....	.....	.....	.....	.....	.....	.....	

Atlantic 100 m. w. (fig. 2).

	90° W.	80°	70°	60°	50°	40°	30°	20°	10°	0°
40°—50° N.	.....	.....	.....	.....	.....	.....	.....	1.500—2.900	275—6.000	
30°—40°	.....	250—460	125—330	75—550	100—300	175—350	125—2.350	300—1.750	250—2.000	
20°—30°	275—425	50—200	60—280	60—200	100—125	165	100— 830	375— 750	.....	
10°—20°	.....	100—230	75—375	250—650	500	375	500	.....	.....	
0°—10°	.....	400—750	.....	.....	.....	.....	.....	.....	.....	

Atlantic 300 m. w. (fig. 3).

	90° W.	80°	70°	60°	50°	40°	30°	20°	10°	0°
40°—50° N.	.....	.....	.....	.....	.....	.....	.....	.....	1.500—2.000	
30°—40°	.....	375—500	250—350	.....	100—125	125	100—650	150—1.250	300—2.250	
20°—30°	125—400	40—150	50—350	75—200	125	250	100—330	375— 500	.....	
10°—20°	.....	75—125	50—300	125—250	150	625	500	.....	.....	
0°—10°	.....	300—500	.....	.....	225	.....	.....	.....	.....	

Atlantic 600 m. w. (1½ meter stramin-net) (fig. 4).

	90° W.	80°	70°	60°	50°	40°	30°	20°	10°	0°
40°—50° N.	.....	.....	.....	.....	.....	.....	.....	.....	100—1.000	
30°—40°	.....	125—325	100—125	.....	75—250	75—175	125—350	.....	.....	
20°—30°	.....	.....	35—100	50—75	50	.....	.....	.....	.....	

Atlantic 600 m. w. (2 meter stramin-net) (fig. 4).

	90° W.	80°	70°	60°	50°	40°	30°	20°	10°	0°
30°—40° N.	.....	.....	.....	.....	.....	.....	200	175	.....	
20°—30°	75—275	15—125	.....	100	.....	.....	.....	.....	.....	
10°—20°	.....	25— 75	25—265	150—175	150	300	250	.....	.....	
0°—10°	.....	125—500	.....	.....	75	.....	.....	.....	.....	

Mediterranean (Winter cruise 1908—09) 25—65 m. w. (fig. 6).

	5° W.	0°	5° E.	10°	15°	20°	25°	30°
40°—45° N.	.....	.....	250—1.500	50—250	35—62	.....	.....	
35°—40°	1.800—1.950	500—600	250—1.500	.....	15—55	20—57	.....	
30°—35°	.....	.....	.....	.....	.....	.....	.....	

Mediterranean (Summer cruise 1910) 25—65 m. w. (fig. 7).

	5° W.	0°	5° E.	10°	15°	20°	25°	30°
40°—45° N.	.....	100—400	.....	200— 300	.....	.....	100—5.000	
35°—40°	660—1.500	100—900	100—1.000	50—1.000	120—300	140—200	180—400	
30°—35°	.....	.....	.....	.....	65—150	90—150	.....	

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REPORT ON THE DANISH OCEANOGRAPHICAL EXPEDITIONS 1908—10
TO THE MEDITERRANEAN AND ADJACENT SEAS
Vol. III. Miscellaneous Papers.

4.

Elvers from North and South Europe.

By

A. C. Strubberg.

With 9 Figures.

Published December 15. 1923.

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INTRODUCTION

In 1913, I published some observations on the development of pigment, and the reduction in length and weight, in relation to certain external features, among elvers from Denmark. Since then, I have had occasion to investigate a number of samples of elvers taken in part during the same season of ascent, and captured, some pelagically, others in course of ascent in various parts of north, west and southern Europe.

The material was for the most part procured on the instigation of Dr. Johs. Schmidt, the well-known leader of the "Thor" and "Dana"s Atlantic expeditions, and by him entrusted to me for investigation. I take this opportunity of expressing my cordial thanks to Dr. Schmidt for placing the work in my hands, as also for the kindly interest and valuable advise which he has always extended to me in my investigations. I am also indebted to Dr. A. C. Johansen, leader of the Fishery Investigation in Danish waters carried out by the Kommission for Havundersøgelser for contributing valuable material from the North Sea and Danish waters. I further wish to thank the following gentlemen: Mr. Cossart, Danish Consul at Madeira, Hr. Lübbert, Director of Fisheries at Hamburg, Proprietær Nielsen, Hov Vig, Sjælland, Denmark, Sr. A. Cesar de Noronha, Madeira, Mr. Paget, Director of Fisheries Research Egypt, Dr. Wallace, Fishery Laboratory, Lowestoft, and Hr. Wassmuth, Danish Consul at Livorno, who have all rendered kindly assistance in procuring samples of elvers and furnishing information as to season of the ascent in widely different localities.

The material for investigation consisted of: A) Three series of samples, being respectively from the Mouth of the Nile, $19^{19}/_{20}$, $19^{20}/_{21}$, $19^{22}/_{23}$, from the mouth of the Arno $19^{22}/_{23}$, and from the Severn (Epney Estab.) $19^{20}/_{21}$, each series consisted of some few samples taken at various times during the particular season of ascent. B) A series of samples of elvers from the North Sea $19^{22}/_{23}$, and C) Several miscellaneous samples from previous years, either of ascending elvers in the Atlantic and North Sea area, or consisting of pelagic elvers from the North Sea.

In all cases, the degree of pigmentation and the average length and weight for the samples was determined in material preserved in formol (4 % formalin). The measurements were taken under water in a flat Petri dish. The weight was determined immediately after slightly drying the specimens by spreading them out and pressing lightly between two cloths.

Table 1 p. 4 shows the sizes of the series from the Nile, Arno, Severn and North Sea.

I. ELVERS FROM THE NILE.

Of these, there were four samples for investigation, sent by Mr. G. W. Paget, Director of Fisheries Research, Cairo. We have to thank Mr. Paget for the first authentic accounts of the enormous ascent of elvers in the Nile Delta, where he has, since 1920, organised the collection of elvers during the season and their transport to the great lakes of the Delta.

Table 1.

m/m	Nile Delta				Mouth of Arno		North Sea					Severn (Epney)			
	1920			1923	1922	1923	1923					1921			
	16/II	3/VII	18/XII	25/I	Med./XII	c. 1/II	12/I	30/I	14/II	9/III	2/V	14/III	26/III	11/IV	23/IV
83	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
82	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
81	—	—	—	—	6	1	2	2	2	1	—	—	—	—	—
80	—	—	—	—	16	2	1	1	5	1	—	—	—	—	—
79	—	—	—	—	23	6	3	1	3	—	—	—	—	—	—
78	—	—	—	—	55	8	4	5	2	1	—	—	—	—	—
77	—	—	—	—	60	25	4	4	13	2	—	4	2	—	—
76	—	—	—	—	98	44	6	17	22	1	—	2	1	2	—
75	—	—	—	—	127	55	9	32	15	2	—	8	1	2	1
74	—	—	—	—	142	105	7	48	12	4	1	8	3	—	—
73	—	—	—	1	171	113	7	64	15	3	—	13	4	6	—
72	—	—	1	2	174	123	6	75	14	3	—	20	8	4	7
71	—	—	4	6	182	149	8	69	13	1	—	19	10	9	9
70	—	—	4	9	174	149	3	75	11	3	1	16	13	7	4
69	—	—	9	7	172	121	5	68	10	3	1	33	23	11	16
68	4	1	22	24	128	105	—	53	10	3	1	23	23	18	22
67	5	1	22	38	147	90	—	45	6	2	2	22	22	16	19
66	7	3	34	41	116	68	2	23	2	2	—	21	29	27	34
65	10	7	39	40	88	38	1	19	—	1	—	14	28	29	25
64	18	13	43	36	48	21	—	9	—	1	—	4	11	24	21
63	18	15	37	22	49	17	—	5	1	—	—	5	10	23	19
62	24	17	31	20	30	7	—	2	—	1	—	3	19	9	18
61	27	12	18	22	15	4	—	2	—	—	—	—	3	12	7
60	23	8	12	9	9	—	—	1	—	—	—	—	—	10	5
59	22	5	4	2	3	—	—	—	—	—	—	3	1	2	2
58	18	3	3	1	1	—	—	—	—	—	—	—	—	1	1
57	6	2	1	1	—	—	—	—	—	—	—	—	—	1	—
56	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
55	3	—	—	—	—	—	—	—	—	—	—	—	—	1	—
54	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total No.	195	87	284	281	2.035	1.251	65	620	156	35	6	218	211	214	210
Average length	61.1	62.3	64.4	65.1	70.6	70.5	73.9	70.6	73.1	72.0	69.2	69.0	67.3	65.6	65.7
Average weight	174	151	222	226	369	340	324	292	285	277	170	313	284	214	210

The samples were from:

16. February 1920, Port Said,

3. July 1920, Mex, Alexandria,

18. December 1920, Mex, Alexandria,

23. Januay 1923, Mex, Alexandria.

The sample from February 1920 was taken during the ascent of the elvers into Lake Menzaleh, the great sheet of water in the eastern part of the Delta. All the others were collected at the pumping station at Mex. This station, which regulates the level of the water in the lake of Mariut, the westernmost of the lakes in the Nile Delta, lies at the end of a canal half a mile long, leading to the sea. The station pumps out daily (except in summer) something over 3 million tons of fresh water out into the sea — the difference in level amounting to as much as 11 ft. And at certain seasons of the year, great quantities of elvers appear here, but are unable to pass the pumping station itself.

According to development of pigmentation, the individuals in the separate samples group themselves as follows:

	Season 1919—20		Season 1920—21	Season 1922—23
	Port Said $^{16}/_{3}$ 1920	Alexandria $^{3}/_{7}$ 1920	Mex, Alexandria $^{18}/_{12}$ 1920	Mex, Alexandria $^{25}/_{1}$ 1923
Stad. V. B.	9	—	21	26
» VI. A. I	78	10	81	58
» » A. II. 1	95	63	76	113
» » » » 2	7	1	100	56
» » » » 3	—	1	5	27
» » » » 4	3	2	1	
» » A. III. 1	1	4	—	1
» » » » 2	1	2	—	—
» » » » 3	1	4	—	—
» » A. IV.	—	—	—	—
» » B.	—	2	—	—
Total No.	195	87	284	281
Size limits (mm)	54—68	57—68	57—72	57—74
Average length (mm)	61.1	62.3	64.4	65.07
» weight (mg)	174	151	222	226

The samples from July and January also contained some individuals whose relatively high weight showed that they had concluded their metamorphosis and commenced to grow (eat). These are here omitted.

The December sample is, as PAGET's observations show, (PAGET 1921, p. 36—37) not from the same season of ascent as the other two 1920 samples, those from February and July.

PAGET gives (l. c.) measurements in the form of graphs for three samples from 1920, taken almost simultaneously with the three sent to us here. His measured samples however, being larger, I have endeavoured to calculate their average length from the graphs with the following result:

	$^{4}{}_{2}$	$^{3}{}_{7}$	$^{15}{}_{12}$
Average length (mm)	61.7	61.6	65.3
Total No.	600	650	280

Arranging the samples according to order of precedence in the season, we get the following:

	December (1920)	January (1923)	February (1920)	July (1920)
Average length	64.4	65.1	61.1	62.3
	65.3	—	61.7	61.6,

the figures at the bottom being the average values calculated from PAGET's graphs.

Minor discrepancies in the figures for the separate months are probably chiefly due to the fact that PAGET's graphs are based on a greater number of specimens than our samples contained.

Our samples are more or less homogeneous in composition, the youngest stages, V A and B being either entirely lacking of very few in number, and most of the specimens being at Stages VI A I and A II, 1[1].

[1] The material was divided according to the scheme put forward by me in 1913 (l. c.) where the separate stages, apart from a further subdivision into phases, were characterised as follows:

Stage V. B. No distinct pigment along base of dorsal fin on body and tail, + cerebral spot + rostral pigment.
Stage VI. A. I + pigment along base of dorsal, O mediolat. pigment.
» VI. A. II + » » » » » » + » postanally.
» VI. A. III + ventrolateral pigment postanally » preanally.
» VI. A. IV + » » preanal.
» VI. B. Diffuse pigment.

It will be noticed that the figures otherwise show considerably higher values for the first part of the season than later on, a phenomenon which, as will be seen in the following, is often discernible elsewhere within one and the same season of ascent.

The values for February and July, both length and weight, are lower than hitherto observed in any season within the area of distribution for *Anguilla vulgaris*.

The *various phases* are not very evenly represented in the separate samples, but it will nevertheless be possible in several cases to trace the reduction in length and weight from stage to stage as noted on a previous occasion. The values for fairly large samples are given below.

	V. B.	VI. A. I.	VI. A. II. 1 & 2.
Average length $^{16}/_{2}$ 1920	62.3	61.33	60.89
» » $^{3}/_{7}$ 1920	—	62.60	62.00
» » $^{18}/_{12}$ 1920	65.1	64.24	64.47
» » $^{25}/_{1}$ 1923	65.5	65.40	64.89
Average weight $^{16}/_{2}$ 1920	191	175	174
» » $^{3}/_{7}$ 1920	—	158	145
» » $^{19}/_{12}$ 1920	245	226	217

The ascent of elvers in the Nile Delta can evidently take place on a very large scale, and at the instigation of Mr. PAGET, arrangements have been made for utilising the extensive material available for transplantation. The fishery commenced in 1920, at the end of January, with a simple system of eel traps in the canal at Mex. From here, in the spring of 1920, close on 6 million elvers were transplanted. The daily catch averaged about 125,000, the maximum abt. 450,000 specimens.

The number of elvers transplanted corresponds roughly to what the *Deutsche Seefischerei Verein* in its best years from 1908 to 1914 was able to send from the establishment at Epney on the Severn (Bristol Channel) which was run by that institution as a centre for capture, purchase and transport of elvers.

With regard to the commencement and extent of the ascent season in the Nile Delta, PAGET (1921—1922) has up to now observed, *inter alia* the following at the Mex Pumping Station:

Season $19^{19}/_{20}$. Investigations commenced 16. Feb., when elvers were present in great numbers. From 1. March to mid April great numbers constantly arriving. Late in April, the pumps stopped (for a week) and a little after, the elvers disappeared, and were not observed again until early July (1—3) a few days after the pumping stopped; this, however, was only a brief immigration of small numbers. In the course of the season, 3 specimens of abt. 50 mm. length were observed.

Season $19^{20}/_{21}$. All through the autumn, no ascent was observed; mid December, the first of this season's elvers appeared both at Mex and Lake Menzaleh. The immigration continued throughout that month, but ceased with the New Year, and was not resumed until the last days of January, when great hosts arrived on the 30—31st. In February and March the ascent again appeared to be lacking, until large hosts again arrived at the beginning of April. After a pause until middle of April, the immigration was resumed, proceeding from 19th April to end of May without a break No summer immigration was observed.

Season $19^{21}/_{22}$. The first elvers appeared on the 11th November, but no great numbers were observed until the period from 20. Jan. to end of February, and again from 23. March—10. April.

Season $19^{22}/_{23}$. The first arrivals were noted as early as 25. October, and immigration went on right up to end December; not until 4. December however, did great hosts appear. After New Year, "run in full strength" was noted, 2.—4. February and again 14.—15. February (This by letter from Mr. PAGET).

It will be seen from the above how irregularly the ascent is distributed throughout one and the same season, and how the time of its commencement may vary from year to year.

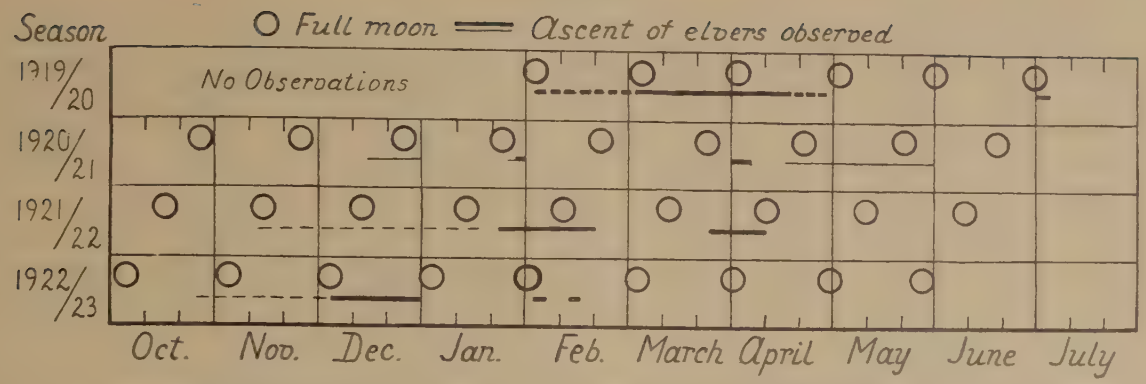

Fig. 1. ○ ○ ○ showing dates of *full moon* and *periods of ascents of elvers* observed at Mex, Alexandria during 1920—1923. — Indicates "run in full strength", the length of line indicating number of days. A thinner line — indicates elvers being less numerous.

It should further be noted, that at Mex, as in the Severn (see p. 15) and elsewhere the great swarms, or commencement of a period of abundance in the arrivals often occurred about the time of full moon, (spring tide).

The foregoing comprises the available material from the eastern Mediterranean, and is all we have up to the present from there.

II. ELVERS FROM GREECE

With regard to the ascent of elvers *in Greece*, some observations have been published by G. Athanassopulos (1921) the form of a preliminary statement.

This writer has been investigating the question for some years past, partly at the mouth of the Alpheos, on the western side of the Morea, and partly in the lake of Koumoundouros, near Athens. He sums up his results as follows:

1) The elvers do not appear in great numbers in the Alpheos until end February—March—April.

2) The phenomenon does not even approximately reach the extent noted in Western Italy.

He has not succeeded in finding the youngest stages, V B and V I A I.

As far as I can make out, the March arrivals in the Alpheos are abt. 65 mm. long, and weigh abt. 150 mg. (average). Failing further data, information as to method of measurement, or actual material, etc. I will not at present make any remarks on this head. The elvers arriving in Lake Koumoundouros are stated to be still smaller and more pigmented, which may perhaps be simply explained as due to their longer stay in the coastal or fresh waters. Here also, however, further information is lacking up to the present.

III. LIVORNO SAMPLES

Through the kind co-operation of Hr. E. Wassmuth, Danish Consul at Livorno, I have obtained two samples of elvers from the season $19^{22}/_{23}$ for investigation. The samples were taken on the 12.—15. December 1922 and early February 1923, both at Calambrone, between the mouth of the Arno and Livorno; they were preserved in 2% formalin. The sizes will be seen from Table 1 (p. 4).

Other features in the samples are as follows:

	Mid December	Early February
Stad. V. B.	280	61
» VI. A. I	1 588	430
» » » II 1	132	340
» » » 2	22	61
» » » 3	13	30
» » » 4	—	2
Total No.	2 035	1 251
Size-limits (mm.)	82—58	81—61
Aver. length (mm.)	70.6	70.5
» weight (mg.)	369	340

Compared with the sample from the Nile Delta 27. January 1923 (p. 4) i. e. from about the same period of the same season, these two Livorno samples show a value of abt. 5 mm higher in the average size. and abt. 120—150 mg. in the average weight.

In the Livorno sample from February, the youngest stages, V. B. and VI. A. I amount to abt. 40 %; in the Alexandria sample, the corresponding stages amount to nearly 30 %. The averagc length and weight for corresponding stages are as follows:

VI. A. I Livorno 70.59 mm. & 341 mg. — Alexandria 65.40 mm. & 227 mg.
— II 1 » 70.33 » » 340 » — » 64.89 » » 228 »

In the Livorno samples also, some reduction in length is apparent from stage V. B. to VI. A. II.

From each of these two samples, a number of specimens were taken immediately after capture (54 and 83 respectively) placed alive in fresh water and sent to the Carlsberg Laboratory here together with the preserved samples by direct steamer. The water was changed daily, but no food was given. On arrival, these samples were fixed in 4 % formalin, and their sizes were then as follows:

Killed	29. January 1923	21. March 1923
Average length (mm.)	67.5	66.8
Average weight (mg.)	290	237

Compared with the size of the specimens preserved immediately after capture, the loss in length and weight respectively appears as follows:

abt. 45 days (Dec./Jan.)
abt. 3.1 mm. and
abt. 80 mg.

abt. 50 days (Feb./March).
abt. 2.8 mm. and
abt. 100 mg.

Some aquarium experiments which I made at Carlsberg Laboratory (l. c.) with elvers from the shores of the Kattegat showed the following reductions in length and weight.

46 days, April/May, fresh water, temp. 16—22°
abt. 2.1 mm. and
abt. 70 mg.

i. e. figures agreeing fairly well with those noted above.

We have also some earlier samples from the same locality (Calambrone), including one from 27. January 1911. The measurements for this, which I took myself, are given by Johs. Schmidt 1911, p. 140. The average size of the 1625 specimens was only 67.71 mm., average weight abt. 280 mg.; Stages VI. A. I and II were most numerously represented.

Further, GRASSI (1919) has given a series of measurements of Italian elvers, *inter alia* from Calambrone and the mouth of the Arno itself. The samples themselves I have not seen, but they show, not only a considerable variation in the average length from year to year, but also — a point which GRASSI himself emphasises — a marked decrease in the average size in one and the same season as the season advances

The figures given below illustrate graphically the average sizes based on his measurements of samples from the seasons $19^{12}/_{13}$, $19^{13}/_{14}$, $19^{14}/_{15}$ and $19^{15}/_{16}$, only taking the youngest stages[1]. We find in these stages a decrease in length of 5—7 mm. in the course of the season.

It will be noted that both our 1911 sample, and the samples from $19^{22}/_{23}$ answer more or less to those measured by GRASSI; the Feb. 1923 sample, however, has a somewhat higher average length, abt. 70.5 mm., than any of his from the same time of year, this, however, without allowance for possible slight difference between his method of measurement and our own. The weight of GRASSI's samples was not determined.

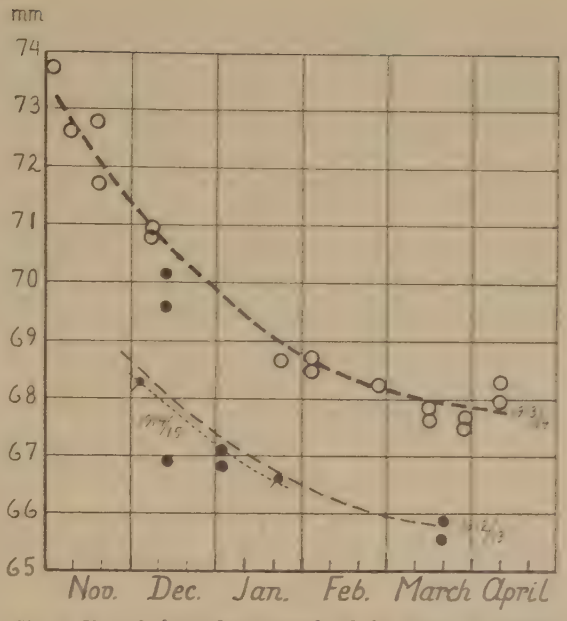

Fig. 2. Size of elvers from mouth of the Arno. Cf. GRASSI.

The season of ascent here — in Liguria — commences in October November; as times, as GRASSI's samples show, already in September, and lasts until March—April or even May, with this reservation, however, that the height of the season falls as a rule from November to February. As far as I am aware, no precise information as to this feature is extant for Italian waters.

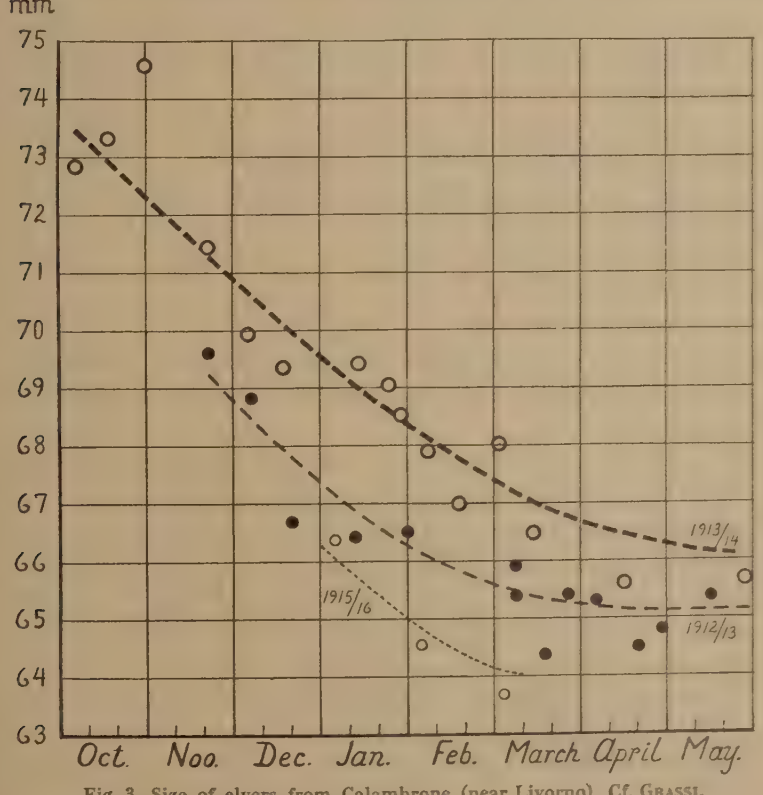

Fig. 3. Size of elvers from Calambrone (near Livorno). Cf. GRASSI.

The season on the shores of the Adriatic probably falls as a rule during the period from February to March (April) but we have only scanty and occasional information, partly from the Comacchio Lagoon, from Venice, and from Lake Vrana, south of Zara[2].

The comparatively late commencement of the season here, as compared

[1] GRASSI employs a rather summary method of division into stages. As far as can be seen from his figures (l. c.) his stages 1 2 and 3 answer most nearly to our V. B. and VI. A. I, his stages 4 and 5 to our VI. A. II 1 & 2. Stages 4 and 5 constitute the greater part of the material throughout the season.

[2] In a letter dates 4. December 1920, Dr. EMIL DOLJAN, since deceased, states that the ascent into Lake Vrana generally commences mid March, or abt. $1^1/_2$ month later than in the Comacchio, where the sluices are kept open every year from the beginning of February to allow the elvers to enter the lagoon. (Cf. also "Der Aalfang in den Lagunen von Comacchio und Venedig", Mitt. Deut Seef. Vereins 1908).

with what we find on the western shores of Italy, may presumably be ascribed to the lower winter temperature on the north and east coasts of the Adriatic (mean temp. for January at Trieste 4.7°, and still lower in the Comacchio, abt. 3—4°, as against abt. 8—9° in Liguria).

From the remaining part of the western Mediterranean, we have here only a very few isolated samples, which do not afford material for further observations. We have, however, from the coast of Spain a series of investigations made during the past few years, which it will be interesting to consider further.

IV. ELVERS FROM SPAIN

Dr. A. G. Hornyold has in a series of papers (1916—1920) given detailed observations as to the duration of the elver season and the weights of material collected for the most part by himself from the Balearic Islands, Valencia (outflow from the Albufera Lagoon) and certain places on the Atlantic shore of the Peninsula. By far the greater part of the material is from the Balearic island Majorca where Dr. Hornyold in March—June 1918 and Feb.—October 1919 followed the progress of the elvers in their ascent of waterways flowing out into the bay at Palma, supplemented by some few samples from here and from Soller, a small port on the north-west coast of Majorca, taken in January 1920.

A single sample, from 14. January 1920, is from the ascent of the elvers at Valencia.

From the Atlantic coast, there are a series of samples from Santander, chiefly from the period January—May 1918, and also another series from the mouth of the Tagus (Lisbon) in March—April 1917, supplemented by a single one taken 27. December 1920.

All the samples from 1918—20 were treated with formol, the stages determined, and weights and measurements taken by Dr. Hornyold according to the method indicated by me (l. c.).

The most interesting part of these investigations lies in the Balearic samples, this is the only material of elvers in their ascent hitherto collected from the Mediterranean in which the samples have been analysed both with regard to size and development of specimens according to a system permitting direct comparison with my analyses of samples from other waters.

Hornyold gives the duration of the seasonal ascent as follows: Albufera (Valencia) October/March, and Bay of Palma (Majorca) September/April; this, however, only applies to the main ascent. At Palma, he found elvers in the youngest stages at nearly all seasons of the year, though only in quite small numbers outside the season proper.

The Balearic Islands present, however, an unfavourable field of observation in as much as most of the watercourses there are small, and often dried up altogether for part of the year. The elvers are thus prevented in moving up into fresh water immediately on reaching the shores, and compelled to remain there until a fall of rain again fills the watercourses and enables them to move up inland. Only a very few of Hornyold's samples thus contain quite young elvers, Stages V. B. — VI. A. I, and even such samples do not consists exclusively of these. Furthermore, special local conditions, waterfalls and other hindrances present additional difficulties in the way of the ascent, and thus also of collecting material.

The only samples in which Stage V. B. is at all abundantly represented are three from the Bay of Palma, and the one sample from Valencia above mentioned.

Taken as a whole, the analyses of these four samples show the following numbers and average sizes for the separate stages:

	Stage V. B. mm./mg.	VI. A. I. mm./mg.	VI. A. II. mm./mg.	VI. A. III. mm./mg.	VI. A. IV. mm./mg.	Total mm.	Total mg.
14. Jan. 1920. Perello (n. Valencia)[1]	66.3/345	66.6/332	66.8/341	—	—	66.5	341
1.—4. Febr. 1919. Riera (n. Palma)	64.6/304	— /296	64.0/310	64.6/296	— /236	64.8	306
6.—11. April 1918. El Molinar (n. Palma)	65.4/328	64.5/309	63.9/296	62.5/274	62.0/283	63.9	300
4.—25. June 1918. Porto Pi (n. Palma)	65.0/247	— /230	63.5/246	63.3/234	— /260	63.9	245
[1] Number	91	39	21	—	—		

The sample from El Molinar shows that the reduction in course of the last part of metamorphosis can amount to abt. 3 mm. and abt. 50 mg. from Stage V. B. to Stage VI. A. IV. 3. On the whole, however, none of Hornyold's many other samples show such high values for the reduction, at any rate, not as regards the average length. The somewhat blurred picture presented by the Balearic samples in this respect is presumably due to the peculiar conditions which retard the ascent from the coastal waters, where the earlier arrivals are constantly being mixed with elvers coming in later.

For the same reason, probably, the series of samples from 1918 and 1919 do not show quite distinctly the decrease in size of the elvers as the season advances, which is so well known from other waters. I have endeavoured to calculate the total sizes (average length and weight) for the separate samples, on the basis of weights and measures stated by Hornyold for the individual specimens, and found the following values:

			No. of Stages V. B.	VI. A. I.	II.	III.	IV.	VI. B.	Length mm.	Weight mg.
1918. March	19—30	Porto Pi	2	4	12	28	26	(5)	62.4	258
» April	5—12	Riera	3	5	134	329	142	(11)	63.8	254
» »	6—11	El Molinar	194	81	227	129	104	(23)	63.9	300
» »	18—30	» »	2	2	45	45	21	—	63.5	287
» »	22—30	Riera	»	»	165	226	88	(15)	64.6	285
» »	19—24	Porto Pi	7	2	52	55	51	(8)	62.8	255
» May	9	Riera	4	3	32	40	48	(11)	63,6	278
» June	4—25	Porto Pi	10	4	31	36	51	(200)	64.0	245
1919. Febr.	1— 4	Riera	129	34	585	114	5	(1)	64.8	306
» »	12—15	»	3	—	37	118	31	(2)	64.9	250
» »	18	»	—	—	—	114	40	(1)	64.3	283
» »	26	»	—	—	41	149	57	(3)	64.6	284
» April	8	El Molinar	—	—	—	38	40	(34)	—	245
» »	13	Riera	—	—	—	81	95	(21)	63.1	262
» May	8	»	—	—	—	3	45	(34)	53.8	215
» »	20	»	—	—	—	1	2	(57)	—	—
» October	28	»	—	—	44	29	4	(5)	650	276

Apart from possible annual variations, which the material from its heterogeneous composition, cannot help us to decide, the size of the young elvers in January (Perello) seems to be abt. 66—67 mm. and abt. 350 mg. (formol-fixed material) and in the course of the spring abt. 65 mm. and abt. 300 mg. (in July only abt. 250 mg.). Stages VI. A. III, which are far more numerously represented in the material, and comprise the last phases of development to the bottom stage before feeding begins, show the following values:

in January	abt. 64 mm.	abt. 300 mg.
in April 1918	» 64 mm.	» 250—270 mg.
in » 1919	» 62.5—62 mm.	» 240—260 mg.
in June 1918	» 63 mm.	» 210—220 mg.

The total averages for the separate samples (all stages taken together) lie between abt. 64,5—65 mm., abt. 300 mg. for January and abt. 63—63.5 mm., abt. 250—280 mg. for most of the samples in April (1918 and 19). A single sample (8. May 1919) shows an average as low as 63.8 mm. and abt. 215 mg., whereas the June samples (1918) again have a somewhat higher weight, abt. 250 mg., but the same length.

Altogether, then, the elvers both from the Balearic Islands and from the eastern side of the Iberian Peninsula (Valencia) seem from this to be, at any rate in certain year, somewhat smaller both in length and weight than those arriving at the same season on the eastern side of the Tyrrhenian Sea. This, however, is a point we cannot discuss further until a greater quantity of material from both areas has been investigated by one and the same observer.

Hornyold's analyses of the series from the Atlantic coast include samples from a) Santander and b) Lisbon. a) The Santander samples[1] shows the following values:

Santander	1917 Nov. 26	1918 Jan. 15.	Febr. 12.	March 29.	April.	May 22.
Total No.	99	124	209	(7)	99	145
Average length (mm.)	76.7	72.2	70.2	(69.4)	70.9	67.4
» weight (mg.)	529	398	429	(384)	430	351

The samples are for the most part composed of stages VI. A. II.—IV. and the entire series shows a regular and considerable reduction in size of abt. 9 mm. and abt. 170 mg. for the period from November to May.

It should be noted that Hornyold has not made a special study of the ascent on this, the Cantabrian coast, but investigated the series chiefly for purposes of comparison with material from the Balearic Islands taken in the same season, and he calls attention to the conspicuous difference in regard to size apparent in his samples from the two areas. These show, in his opinion, that the individual specimens are not only longer on the average, but also heavier in proportion in the Santander samples.

Johs. Schmidt (1906 and 1909) has investigated some samples from the same range of coast and the inner part of the Bay of Biscay.

	December 1906 ($19^{06}/_{07}$) Santander V. B.—VI. A. I.	December 1906 ($19^{06}/_{07}$) San Sebastian V. B.—VI. A. I	January 1906 ($19^{05}/_{06}$) Bayonne V. B.—VI. A. II.
Average length mm.	73.32	75.64	73.59
» weight mg.	—	abt. 500	abt. 350—375

Despite some variation from place to place (and from season to season) the values found agree very well with those found by Hornyold for November/January (Season $19^{17}/_{18}$). (Cf. also fig. 8).

Grassi (l. c. 1919) has measured two samples, one from Deva, between San Sebastian and Bilbao, and one from Hendaye, on the Franco-Spanish frontier, and found corresponding size in the season 1913—1914 for elvers in part somewhat older.

	November 26. 1913 Deva	Januar 18. 1914 Hendaye
Average length	75.96	73.9

It is on this coast that the greatest Spanish elver fishery takes place, during the season from October—November to April. The elvers are sold either for consumption in a fresh state or to the canning companies. Hornyold quotes from B. Rodriguez, in "Las Angulas del Cantabrico" that at Santander, for instance, there is an annual yield of abt. 25,000 kilos, and in the river Nalon, west of Gijon, abt. 51—52,000 kilos. The

[1] Dr. Hornyold states in a letter dated 16. Decr. 1922 that he collected a sample of elvers from Bilbao on the 9th of that month. 100 Stages V. B.—VI. A. I., 29 Stages VI. A. II, 3—VI. A. III.—IV. The 100 measured 73.8 mm. and weighed abt. 460 mg. after formol treatment, i. e. sizes corresponding to those noted from $19^{17}/_{18}$ and 1906.

fishery at the last named station is the largest on the north coast, but fishing is also carried on in each of the provinces of Lugo, Oviedo (Asturia) Santander, Biscaya, Guipuzcoa, so that the total quantity of elvers annually disposed of in this far from economical manner must be very considerable.

b) HORNYOLD's small samples from the Lisbon area are for the most part from the 1916—17 season. All were taken in Jamor in a little river flowing out into the Tagus near its mouth, and the specimens were killed with 10% formalin. The writer was not then able to separate the various phases of Stage VI. A. in the manner afterwards employed, but it appears from his statements that almost the whole of the Jamor material was composed of Stages VI. A. III. and those following, i. e. comparatively old elvers. By way of example, the following analysis may be given, which, as will be seen, despite great fluctuations from one sample to another yet agrees well enough with the Biscay samples from the same time of year, but taken in the following season, $19^{17}/_{18}$.

	December (1917) 27.	March 25.	April 13.	May 10 & 16.	July 8.
No.	55 (VI.A. II)	25	18	33	?
Average length mm.	70.3	68.2	67.3	69.0	66.6
Average weight mg.	405	341	331	479	429

V. ELVERS FROM MADEIRA

A small sample of elvers from Madeira has been received from Sr. A. CESAR DE NORONHA, through the agency of Mr. COSSART, the Danish Consul. On the 2. May and 12. July 1921, numbers of elvers were observed moving up a small stream in Madeira. The observations, however, were not sufficient to show the extent of the season, etc.

The sample from 2. May 1921, preserved in formol, contained 45 specimens.

Stage V. B.	10	Average length	66.9 mm.
» VI. A. I.	6	» weight	282 mg.
» » » II. 1—4	29		

The lengths noted answer fairly well to those found by HORNYOLD at Biscaya and Lisbon in April—May 1917 & 1918.

VI. ELVERS FROM THE SEVERN

THE EPNEY SAMPLES

Dr. WILLIAM WALLACE, of the Fisheries Laboratory, Lowestoft, collected and sent us, on request, 4 samples of elvers from the season March—April 1921. These samples were taken at intervals of 14 days at Epney-on-Severn, Gloucester, abt. three quarters of a mile from the Epney Establishment which was opened by the Deutsche Seefischerei-Verein in 1908 and carried on until 1914 as a centre for purchase and forwarding of elvers in a live state.

The 4 samples from 1921, each of which was taken from the hauls of a single night, shows the following values:

	$^{14}/_{3}$	$^{26}/_{3}$	$^{12}/_{4}$	$^{23}/_{4}$
V. B.	5	—	3	—
VI. A. I	16	14	17	2
» » II. 1	53	26	21	12
» » » 2	51	60	68	12
» » » 3	42	37	18	40
» » » 4	40	40	41	57
» » III. 1	11	34	19	19
» » » 2	—	—	17	28
» » » 3	—	—	7	23
» » IV.	—	—	—	12
» B.	—	—	—	5
Total No.	218	211	211	210
Size limits (mm.)	59—77	59—77	55—76	58—74
Average length (mm.)	69.03	67.29	65.61	65.71
Average weight (mg.)	313	284	214	210

We find here, as might be expected from the position of the station above the broad lower reaches of the river, only a few of the very youngest stages in the samples. Most of the specimens represent phases of Stage VI. A. II., i. e. with postanal pigmentation in full development. For the rest, the samples distinctly show how the average size here also decreases in the course of the period from mid March to mid April, even disregarding the last April sample, where still older stages (A. III.—IV.) are comparatively numerous.

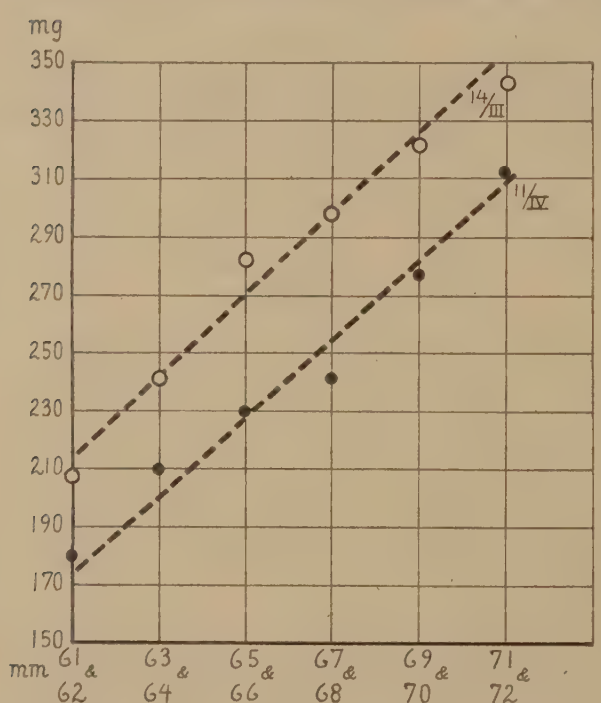

Fig. 4. Elvers from 14. March and 11. April 1921. Severn.

Not only has the average length decreased, however, but the weight of the elvers is also still smaller in proportion.

If we thus compare the measurements and weights of the specimens at Stage VI. A. II. 1 & 2 from 14. March and 11. April, calculating the average weight for the specimens of 61—62, 63—64, 65—66 mm. we find the values given in fig. 4.

It will be noticed that while the elvers of 65—66 mm. for instance, in the 14. March sample weighed abt. 280 mg., the corresponding lengths in the 11. April sample show only a weight of abt. 230 mg.

The reduction within one and the same sample from stage to stage is in some cases distinct, but in others, the individual numbers are too small to give any reliable view of the position.

We have measurements of single samples from earlier years in the Severn, some of which have been published by Johs. Schmidt (1911) and others by Lübbert (1911).

Lübbert measured his 1911 samples in a fresh state and this alone renders his method of measurement incomparable directly with ours. Furthermore, his samples vary greatly in size. Reckoning with a shrinkage of 2—3 mm. in process of fixation, however, his large April sample does not differ greatly from our April sample (1923) or from the May sample (1909) previously mentioned.

For the rest, the samples exhibit great variation from year to year; the elvers seems to have been

Date	No.	Stage	Aver. length (mm.)	Aver. weight (mg.)	Observator
4. April 1908	176	—	75.57	—	Lübbert
16. » »	365	—	76.20	—	»
ult. » »	225	*V.* B.—*V.* A. II.	73.20	310	A. Strubberg
Beg. May 1909	1326	*V.* B.—*VI.* A. I.	68.09	280	Schmidt
16. March 1911	375	—	70.62	—	Lübbert
17. April »	1567	—	70.19	—	»
Med. » »	500	—	—	228	A. Strubberg

particularly large in 1908. It is uncertain whether LÜBBERT's measurements were here also taken from unpreserved material; if so, then the measurements given by him would have to be reduced by abt. 2—3 mm., but in any case, our samples from the same year also show an anually high average length for Epney (range of variation 65—80 mm.). The few scattered samples cannot yield any further information as to the decrease in size (length and weight) of the elvers within one and the same season.

The ascent of elvers in the Severn is well-known as one of the most considerable instances of this phenomenon in northern Europe. LÜBBERT, in his reports on the work of the Epney Station in 1908—1910 gives some particulars, *inter alia*, as to annual variation in the time at which the ascent commences and the extent of the immigration involved. He has also kindly placed at our disposal a copy of the Station journals for the latter part of its period of activity (1911—14).

During 5 of the years from 1908—14, the principal fishery fell during the period from mid March-mid April. In 1909, January to March was unusually cold, and even by the end of March no elvers had appeared; not until mid-April (surface temperature 10°, temp. of the air 7—10°) did the ascent commence, and then at once on a large scale. In 1910, on the other hand, the winter was very mild, and the run was in full swing about a month earlier, viz. mid March. It has generally been found that the great bulk of the elvers only appear during the spring tide periods in March—April in the lower reaches of the Severn (cf. LÜBBERT l. c.). Fishing is carried out at night during the 2—3 days of waxing and 3—4 days of waning spring tide, but the hauls vary greatly according to current, weather conditions etc.

Analysis of the water in the Severn at Epney shows, according to LÜBBERT (l. c.), only very slight salinity, abt. 2‰, but observations covering a long period are lacking. The extracts from the journals contain, *inter alia*, temperature observations from 1912 to 1914 throughout the main season of the ascent. Temperature of the air was often quite low, (2—3° C., sometimes ÷ 1 and ÷ 2), but the surface temperature for March 1913 and 1914 was at 5—7°, and for April of the same years 8—9°. In 1912, the March temperature seems to have been considerably higher, averaging for 1.—14th of that month abt. 7½° as against only 6° in 1914; already on the 21—22 February, 7—9° was noted daily. Simultaneous observations as to the extent of the ascent in this year are lacking, but it is noted in the journals that the surface temperature at times of heavy catches was mostly 7—9°.

No statistics are available for the catches of elvers from year to year. The quantities purchased and caught by the D. S. V. in 1908—1914 vary from abt. 2.5 to abt. 7 million specimens per year, though these figures of course do not represent the whole of the yield. LÜBBERT states, for instance, that one of the station fishermen could take 150 kilos of elvers in a couple of hours, estimated at 350,000 individuals, but this is understood to be far below the maximum. There are times when the yield for the whole Epney area is set at from 2,000 to 2,500 lbs. i. e. at least 2—3 million specimens in the 24 hours.

The D. S. V. closed down the Epney station in 1914, and it was not until 1919 that the British Government resumed similar operations on the spot. There seem, however, to have been certain difficulties in the undertaking, such as lack of sufficient demand for elvers for transplantation purposes; at any rate, it appear to have discontinued its activity at the close of 1921 until further notice.

VII. ELVERS FROM THE NORTH SEA AREA

A. SAMPLES TAKEN IN THE SEA

Danish Investigations 1904—1923.

On the autumn cruise of the Danish research vessel "Dana" in 1922, Dr. A. C. JOHANSEN found, at some stations outside and in the Skagerak a few metamorphosis stages of *Leptocephalus brevirostris*.

The stations in question were as follows:

W. of Skagerak: St. 2860. 2. Oct. — 57° 12′ N. Lat. 7° 52′ E. Long. 50 m.
Young-fish trawl 100 m. wire out. 30 min. Temp.: 0 m. 12°.0, 50 m. 12°.3.
Salinity: 0 m. 34.3‰, 50 m. 34.7‰.
1 spec. 64 mm., Stage IV. B.

Skagerak: St. 2889. 10. Oct. — 57° 37′.5 N. Lat. 11° 28′.5 E. Long. 85 m.
Young-fish trawl 150 m. wire. 60 min. Temp.: 0 m. 10°.2, 85 m. 9°.5.
Salinity: 0 m. 21.4‰, 85 m. 34.8‰.
3 spec. 65, 70, 75 mm. Stage V. A.

St. 2906. 14. Oct. — 57° 41′ N. Lat., 9° 04′ E. Long. 70 m.
Young-fish trawl 100 m. wire. 240 min. Temp.: 0 m. 10°.8, 25 m. 12°,3, 70 m. 9°.0.
Salinity: 0 m. 32.1‰, 25 m. 34.36‰, 70 m. 34.97‰.
1 spec. 60 mm. Stage IV. B.

Kattegat: St. 2923, 18. Oct. — 57° 05′.5 N. Lat., 11° 53′ E. Long. 52 m.
Young-fish trawl 100 m. wire. 120 min. Temp.: 0 m. 9°.5, 50 m. 11°.5.
Salinity; 0 m. 19.3‰, 50 m. 33.8‰.
1 spec. 73 mm. Stage IV. B.—V. A.

These hauls are of great interest, showing as they do that, in certain years at least, hydrographical conditions are such as to permit late metamorphosis stages of *Leptocephalus brevirostris*, or more correctly perhaps, the advance guard of the main hosts from the Atlantic, to cross the North Sea and reach our waters as early as the beginning of October. There can be little doubt but that these specimens made their way into the North Sea round the north of Scotland and not via the English Channel; they supplement BOWMAN's earlier finds of *Leptocephalus brevirostris* in a more or less advanced stage of metamorphosis in the Sea north of Scotland (inside the 1000 metre limit) especially end August (1906, 1910 and 1911). The Danish investigations in the North Sea during previous years have not included pelagic hauls during the autumn months, so that for the present it must be left undecided whether the finds here mentioned are to be regarded as extraordinary or as the general rule.

At any rate, the immigration into the North Sea was continued in the autumn and winter months of $19^{22}/_{23}$, as is shows by the hauls made by the "Dana" during that time.

On the $^{12}/_{1}$, $^{30}/_{1}$, $^{14}/_{2}$ and $^{9}/_{3}$ (1923) the "Dana", Capt. G. HANSEN, fished near the bottom north of Graadyb Lightship, 55° 24′.5 N. Lat., and 8° 12′ E. Long. in abt. 13 m. water[1]. All these hauls, especially 30. Jan., included young elvers. Even as late as 2. May 1923 Dr. A. C. JOHANSEN, on the spring cruise of the "Dana", at 56° 44′ N., 8° 11′ E. 9 metres of water (temperature: 6.1—5.8°, salinity: 33.1‰) working with the young-fish trawl near bottom, took 6 elvers, average 69.2 mm. and 170 mg. Of these, 5 were at stage V. B. and 1 at stage VI. A. I. The samples were preserved, stages determined etc. in the usual manner (except the February sample).

[1] Temperatures: 0 m.: 5.3, 5.0, 1.5 & 1.0°, 13 m.: 8.0, 7.0, 2.8 & 1.5° resp. Salinity: 0 m.: 30.3—29.5‰, 13 m.: 31.9—30.0‰.

1923:	$^{13}/_{1}$ [1]	$^{30}/_{1}$	$^{14}/_{2}$	$^{9}/_{3}$	$^{2}/_{5}$
Stag. *V.* B.	69	547	135	33	5
» *VI.* A. I.	—	73	21	2	1
Total No.	69	620	156	35	6
Size limits (mm.)	65—83	60—81	63—81	62—81	67—74
Average length (mm.)	73.87	70.56	73.06 [2]	71.40	69.2
» weight (mg.)	324	292	285	277	170

The average lengths fluctuate somewhat irregularly; the average weight, on the other hand, shows an uninterrupted decrease from mid-January to mid-March.

A. C. Johansen has previously (1905) published some observations of pelagic elvers for this area and Danish waters in 1905. The specimens were taken pelagically at or near the surface by night, at or near the bottom by day. He has kindly placed his material at my disposal for these investigations. Supplemented by samples subsequently obtained, these samples, quite small in themselves, give the following average values:

Pelagic in	March		April			May
	1905	1906	1905	1906	1907	1905
No.	73	66	25	11	10	22
Average length (mm.)	69.1	70.2	c. 71.5	c. 69	69.2	69.6
» weight (mg.)	227	250	214	266	248	215

Owing to the small numbers, the average values found are not very reliable; the difference in size between the pelagic elvers in 1905 and 1906 is therefore perhaps only apparent, and for the same reason, it is difficult to compare these older samples with those of 1923. The figures for March 1906, however, lie fairly near the corresponding values for the March 1923 sample.

The isolated samples likewise do not permit the demonstration of any decrease in the length and weight of the individuals in the course of any single season, but the January—February samples do certainly show a considerably higher weight per fish than those taken later.

	January	February	March	April	May
1905	—	—	227	214	215
1906	—	—	250	266	—
1907	—	—	—	248	—
1923	324	292—285	277	—	—

Systematic pelagic fishery would enable us to arrive at a clear view also in this respect.

Most of the Danish pelagic hauls were made — as mentioned — in the eastern North Sea and the Skagerak, only very few in the Kattegat, Sound and Baltic, west and east of Bornholm. As mentioned by Johs. Schmidt 1909, Dr. A. C. Johansen working with the "Thor" on the 4. May 1908 E. of Bornholm, in 81 metres of water, took a single specimen pelagically (intermediate) with the young-fish trawl, This is, up to date, the most easterly find from northern Europe[3]. The specimen was 73 mm. long and weighed 380 mg.; it was at stage V. A., i. e. no chromatophores on the head, only tip of tail pigmented.

As regards pigmentation of the other pelagic elvers here referred to from the North Sea and our

[1] This sample was kept alive in an aquarium on board for abt. 10 days before placing in formalin. The average size is therefore probably somewhat lower in proportion to what it was immediately after capture. But the sample as a whole is too small to give any reliable view of the actual average length and weight of the stock at the time it was taken; the same also applies to the sample from March.

[2] Killed in very weak formol and then prepared fully extended (over-stretched?)

[3] Since the above was written, a further work has appeared, viz. O. Nordqvist & Sten Vallin: Untersuchungen über Aalbrut. Wiss. Meeresunters. N. F. Abt. Helgoland, XV. Bd., 1923. Mention is here made of the capture of 1 spec., 69 mm. Stage VI. A. I. near Simrishamn, 55° 34′ N. Lat., 14° 22′ E. Long. 25. Sept. 1922.

Danish waters, practically all specimens show the cerebral spot more or less developed; only few, however, have *rostral* chromatophores, and this applies equally to specimens taken pelagically by night or with bottom working implements in the daytime.

The rostral pigment is only developed towards the close of pelagic life, and at the same time, the pigmentation extends laterally over the end of the tail, with indications of the later myoseptal arrangement and medio-lateral striation, whilê a series of small chromatophores is developed along the entire base of the dorsal fin.

OTHER INVESTIGATIONS

In addition to the previously mentioned Danish finds, and the few hauls from "Thor" chiefly from April 1904 and 1905, mentioned by Johs. Schmidt (l. c. 1906) we have also reports of pelagic elvers taken in the North Sea by G. Gilson 1908 and A. Bowman 1912.

Gilson made investigations in the southern part of the North Sea between Cape Gris-Nez and 52° N. lat., where, in the spring of 1904, 05, 06, 07 and 08, a total of 900 elvers were taken, some pelagically, others at the bottom. Already at the beginning of February (1905, 06 and 08) the pelagic stages were present in the southern North Sea. Unfavourable weather hindered the work at sea earlier in the year, but Gilson opines that the elvers were then (in January) already present in the waters concerned. In this he may be is correct, as compared with the later finds of the "Dana" from Januay and February 1923.

Gilson found unusually large numbers on the 6—8 February 1908 off Cape Gris-Nez, 100—175 per haul, taken with the young-fish trawl at the surface, but only very few in the following days off the Belgian coast. Catches of over 20 specimens per haul were otherwise only made here on the 22—28 May 1907 (off Ostend).

For stage V. B. (taken in 1907 almost exclusively in the last half of May) Gilson finds an average length of 68.2 mm; for more pigmented specimens, taken about the same time at or near the bottom off Ostend, he gives the average length as abt. 67.4 mm. — Unfortunately, nothing further is stated as to measurements of the February samples or those from 1904—06, and nothing as to weight, so that no comparison can be made with the "Dana" samples.

Alex. Bowman has, from occasional catches of *Leptocephalus brevirostris* and the pelagic metamorphosis stages west and north of Scotland and in the northern part of the North Sea, been able to follow the course of their immigration from the Atlantic northward round Scotland into the northern waters of the North Sea in the autumn and winter months.

He considers that "the glass-eels must be off the coast (E. Scotland) as early as December, although the ascent of the rivers is not apparently undertaken much before the month of May." He sums up his observations in the following words: "The *Leptocephali,* in their passage round the North of Scotland, are metamorphosing into glass-eels in the autumn months: that a great stream of them is passing through the northern North Sea about December and thereafter till February; while from this central stream the glass-eels spread coastwards, on either side of the North Sea, reaching the coast about March and April. They then ascend the rivers as "elvers", in May or during the latter part of April, especially during the first half of May."

His measurement show, despite the small number of individuals from the various years, a decrease in length from abt. 71 mm. average length in November (4 specimens) to abt. 68.1 mm. in February (37 specimens) and abt. 65.6 mm. in March (13 spec.)

The greatest numbers, which were taken mid February and 25. March, show the following average lengths:

Mid February	End March
1906	1911
15 spec.	17 spec.
68.3 mm.	65.6 mm.

The finds made by BOWMAN are supplemented by a statement in a letter from Prof. E. EHRENBAUM, the well-known German biologist, to Dr. JOHS. SCHMIDT. According to this, the German seasonal cruises in the open North Sea in February and March 1905 took 4 pelagic elvers. Further particulars are as follows:

1905	14. Februar	56° 02′ N., 3° 16′ E.	1 spec.	70 mm.
	15. »	57° 24′ N., 3° 41′ E.	1 »	68 »
	20. »	57° 7′ N., 7° 47′ E.	1 »	73 »
	18. March	Norderney 10 m.	1 »	76 »

(at night, surface).

These finds entirely confirm BOWMAN's view.

It should here be mentioned that the few younger metamorphosis stages (mostly stages II.—III.) of *Leptocephalus brevirostris*, which BOWMAN obtained in the waters N. W. and N. of the Hebrides, chiefly in August 1911, had an average length of abt. 70.2 mm. (11 spec, BOWMAN's measurements).

B. FRESHWATER SAMPLES FROM THE DANISH COASTS

Since A. C. JOHANSEN, in 1905, published his observations and measurements of both pelagic elvers and those in course of ascent into West Jutland waters, no fresh material of any importance has been gathered regarding the ascent. In 1906—1911, some occasional samples of elvers were obtained both from the North Sea and Kattegat coasts. But it would require a continual series of observations from one or more suitable localities to enable us to follow the course of the ascent throughout any single season, and possible variations in the same from year to year, and no such investigations have as yet been organised, with the exception of those mentioned below from the Isefjord.

Only rarely has any ascent been noted before March, and most frequently in April and May. Even in years (1923) where great hosts of pelagic elvers were found off the west coast of Jutland in January, February, the actual immigration into fresh water did not begin on any considerable scale until spring set in, with rising temperature, at the end of March.

It is only on the Isefjord, in North Sealand, where Proprietær Nielsen has set up an eel breeding establishment on a large scale, that observations have been made covering a period of years as to the commencement and duration of the ascent; Hr. Nielsen has kindly communicated the following information on this head.

	Fishery commences	Greatest yield	Fishery ends
1912	$^{9}/_{3}$—$^{24}/_{3}$	April—mid May	$^{29}/_{5}$
1913	$^{15}/_{1}$	$^{26}/_{3}$—April	$^{4}/_{5}$
1914	$^{18}/_{2}$	$^{30}/_{3}$—mid April	—
1915	$^{22}/_{3}$	$^{5}/_{4}$—mid May	$^{29}/_{5}$
1916	$^{16}/_{3}$	mid April—end May	$^{6}/_{6}$
1917	$^{29}/_{4}$	May	$^{30}/_{5}$
1919	—	$^{9}/_{4}$—end April	$^{12}/_{5}$

Here also, according to the information given, the main ascent does not take place until April and May.

As regards the Size of elvers on the Danish coasts, I can here supplement the information furnished by A. C. JOHANSEN (l. c. 1905) and JOHS. SCHMIDT (l. c. 1906) by giving the length and weight of some samples later to hand. In addition, the values for some older samples now determined as to weight and stage are also noted.

North Sea Coast.

Streams near Esbjerg.

	Date	No.	Commonest stages	Aver. length mm.	Aver. weight mg.
1905	$^{26}/_{4}$—$^{6}/_{5}$	228	*V.* B.—*VI.* A. I.	71.4	270
	$^{9}/_{5}$	90	*VI.* A. II.	70.3	230
	$^{22}/_{5}$	261	*VI.* A.—III.—IV.	69.2	185
1906	$^{10}/_{4}$—$^{19}/_{4}$	47	*VI.* A. I.	69.5	255

Nymindegab (Mouth of Ringkøbing Fjord).

	Date	No.	Commonest stages	Aver. length mm.	Aver. weight mg.
1905	$^{2}/_{6}$—$^{3}/_{6}$	314	*VI.* A. IV.-*VI.* B.	67.9	260[1]
	$^{7}/_{6}$	126	» »	66.7	—
1908	$^{5}/_{4}$	7	*VI.* A. I.	71.7	245
	$^{12}/_{4}$	28	*V.* B.—*VI.* A. I.	69.7	236
	$^{26}/_{4}$	51	» »	70.3	236
	$^{11}/_{5}$	5	*V.* B.	69.4	255
1910	$^{20}/_{4}$—$^{26}/_{4}$	316	*V.* B.—*VI.* A. I.	67.7	230

Kattegat coast.

Stream near Frederikshavn.

	Date	No.	Commonest stages	Aver. length mm.	Aver. weight mg.
1907	$^{12}/_{4}$	39	*V.* B.—*VI.* A. I.	69.2	245
	$^{4}/_{5}$	56	A. II.	69.1	165

Hov Vig (Isefjord).

1912	$^{2}/_{4}$	721	*V.* B.	70.2	204

The young elvers from 1905, end April early May, correspond fairly well in point of size to the pelagic elvers from April of the same year (see p. 17), that is to say, as far as length and weight can be determined from the small numbers available. The sample of young elvers from 1910, end April (Nymindegab), shows essentially lower values for length and weight. For 1908, the measurements of the young elvers from April—May were taken from material preserved in alcohol, so that a certain correction for shrinkage is necessary, say 3—4 mm. The average length then appears as higher than previously found for corresponding stages on Danish coasts; a point of some interest when compared with the observations from the Severn for season 1908, where the elvers likewise appear to have been of extraordinary size.

The elvers in their last metamorphosis stage, just at the commencement of the feeding and growth period, are, from observations up to date, as a rule 66—67 mm. average length, with an average weight ranging from 150—180 mg. Weights below this have up to now only been observed on a single occasion, viz. in a sample taken by Dr. A. C. Johansen in the middle of 1899, in the Ribe Aa, near Ribe. Out of 86 specimens, 66 gave an average weight of only 100 mg., and 20 others, which had apparently begun feeding, 160 mg.

As to how far there is any regular decrease in size of young stages throughout the season in West Jutland we cannot as yet determine, though certain of the figures, e. g. those for the pelagic samples of 1923 seem to suggest that this is the case. Series of sufficiently large samples are lacking up to the present, but even these might when obtained fail to present a perfectly clear view of the position. In a season such as 1922—23 for instance, a great part of the elvers doubtless remained off our North Sea coast during several month of the winter without entering upon their ascent into fresh water; the first comers would

[1] Some of them had begun feeding, their weight is therefore on the increase.

then become mixed with later arrivals, whether coming by way of the English Channel or round the north of Scotland. There would thus be every reason to expect irregular fluctuations in the sizes during the first part of the season (see for instance the first samples for 1923).

GENERAL REMARKS

A. It is a well-known fact that the commencement of the season of ascent varies for a given locality from year to year, and fresh data have been communicated in the foregoing to illustrate this point. And from what we now know, thanks to the clear and incontestable results of Dr. SCHMIDT's investigations, as to the breeding grounds of the eel in the western Atlantic, and its long pelagic larval life, the ascent of the elvers also appears in another light than heretofore; it now becomes natural to regard it as a whole, and not as a series of isolated phenomena occurring separately in north, west or southern Europe.

In the course of its first two years of life, Leptocephalus brevirostris will have moved from the western Atlantic in a north-easterly direction, so that by the commencement of its third year, it will have reached the vicinity of western Europe, and — for a great portion of the stock — into the Mediterranean. In June, the eastern limit of occurrence for full-grown leptocephali in the Atlantic will lie comparatively near the continental slope, while the eastern limit in the Mediterranean will be west or east of 15° E., the exact position being determined, in both cases, *inter alia* by the hydrographical conditions during the progress of the larvæ, and thus often varying from year to year. The oldest specimens have now concluded their larval growth; metamorphosis sets in, and continues throughout the following months; the migration going on all the time along the western side of the continental slope in the Atlantic and farther to the eastward in the Mediterranean, or here, in the case of some of the larvæ, circulating with the movement of the water in the various western basins of that sea. (Cf. Dr. J. N. NIELSEN, 1913).

In Fig. 5 will be seen the dates for commencement of the ascent in $19^{22}/_{23}$ and some earlier seasons at various localities in north and south Europe. Month of capture for the latest semi-pelagic stages (V. B. & VI. A. I.) in the North Sea and Danish waters are also shown.

It will be seen that in $19^{22}/_{23}$, the elvers (Stages V. B. & VI. A. I.) were able to commence their ascent at about the same time (October—November) in the western Mediterranean, the Nile Delta, and the Bay of Biscay, while great hosts of stages entirely corresponding were then waiting out in the North Sea close to the Danish coast. The ascent here, however, did not begin until much later (April/May) this being, probably most likely, due to the lower winter and spring temperature of the fresh water here.

The retarded ascent in the $19^{22}/_{23}$ season for the North Sea coast as compared with those of southern Europe was thus chiefly due to conditions of temperature. As to how far this is always the case we cannot determine until further investigations have been made in open sea, but the above-mentioned pelagic hauls in the North Sea during the autumn months of 1906—1908 and other years (see p. 18) show that the $19^{22}/_{23}$ season was at any rate not unique for the water concerned in this respect.

Since the rate of metamorphosis is accelerated by higher temperature, it is indeed not unlikely that further investigations in southern waters might show an earlier commencement of metamorphosis or a more rapid completion of the process in the Mediterranean than in western European waters; the results of the $19^{22}/_{23}$ observations, however, do not seem to indicate the probability of any marked difference in this respect.

For the rest, as regards the Mediterranean, it would seem that the north coast of the Adriatic, for instance, also shows some indication of a slight retardation in the ascent as compared with the western coast of Italy. We have thus here a possible counterpart of the conditions on the North Sea coast, due to the lower winter temperature of the coast land.

That the ascent in the Nile Delta, at any rate in certain years, as in $19^{22}/_{23}$, commences at about

the same time as in western Europe, may be explained as due to the fact that in certain years, the eastern limit of occurrence for the fully-grown Leptocephali lies far to the east in the Mediterranean, Otherwise, the eastern movement of the water along the entire coast of North Africa is probably always an important factor in the rapid eastward movement of the metamorphosis stages. The great outflow of fresh water from

Fig. 5. Earliest dates for ascent of elvers and finds of pelagic glass-eels observed. Season $19^{22}/_{23}$ and earlier seasons. See text.

the Nile Delta may also count for something here, as it might well be supposed to exert a certain influence upon the very active, latest pelagic stages attracting them from some considerable distance.

Altogether, we may say that supposing the metamorphosis period of the larvæ to be constant from year to year in commencing during summer, the determining factors for date of the ascent in a given water will be:

1) The length of time required under the prevalent hydrographical conditions for metamorphosis and migration of the pelagic stages to the coastal water concerned, and
2) Temperature of the coastal water in question[1].

The actual immigration shows as a rule one or two pronounced maxima, these lasting at times for some few days, at others for several weeks. In some cases (e. g. the Severn) it has been found that the great hosts of elvers only make their appearance during the periods of spring tide in the spring months; in other localities (e. g. the Nile Delta) the maxima of the individual seasons may in part be otherwise distributed.

The period of ascent may extend over 5—6 months[2], but as a rule, the main ascent seems to be concluded within a far shorter period. Most statements as to duration of the season cover just this period. In reality, however, the systematic investigations which have been undertaken at certain localities show that isolated occurrence of elvers may be noted throughout a far greater part of the year, at the Balearic Islands, for instance, in all seasons of the year.

B) In comparing the size of the elvers as between one water and another, it is necessary as far as possible to restrict observations to samples consisting of true elvers, i. e. the youngest bottom stages[3].

The marked reduction in size which takes place simultaneously with development of pigment, and which may also be further influenced by local conditions, renders it impossible to draw certain conclusions from material consisting exclusively of older stages as to the size of the elvers at the moment of ascent.

The task is further impeded by the not inconsiderable annual variation at a given locality. The best basis for comparison is found only in large samples (Stage V. B. VI. A. I) from one and the same season, and — which is not the least important point — treated in the same way and investigated by the same observer.

Only a few of the samples hitherto available fulfil all these requirements. In the figures given below, 6—9, I have collected all the material which in my opinion is best suited to the purpose for a survey of the position in 1) The North Sea area, 2) Western Europe (South-west England and Ireland, Bay of Biscay) and 3) The Mediterranean.

Figs. 6 and 7 illustrate the conditions for the season $19^{19}/_{20}$, $19^{20}/_{21}$ and $19^{22}/_{23}$ according to my own investigations.

These figures both show that the elvers of the Nile ascent for the season $19^{19}/_{20}$, $19^{20}/_{21}$ and $19^{22}/_{23}$ are inferior both in length and weight to these of the Severn and the North Sea, and furthermore, to those of Livorno.

[1] Exceptional conditions, as for instance those noted in the case of the Balearic Islands (see p. 10) where the small water-courses are only accessible after heavy rain, may of course also serve to retard the ascent.

[2] Cf. *inter alia* the observations from the mouth of the Arno and the "Dana" finds of pelagic elvers (Stages V. B. IV. A. I.) in the North Sea during the season $19^{22}/_{23}$ from October right on to May.

[3] The terms "*glass-eel*" for the unpigmented, and "*pigment eels*" for elvers with more pronounced pigmentation comprise together the last stages of the metamorphosis, which are passed through in coastal regions, in very shallow sea or fresh water. In these stages, the reduction in size is continued and completed, and here too life near and at the bottom commences. They can therefore be taken together as "*bottom stages*" in contradistinction to the previous "*pelagic*" stages. The limit between them is formed by Stage V. B., representing both the last pelagic or semi-pelagic stage and the first stage of the elvers moving up into fresh or brackish water.

Growth Stages		Reduction Stages (Metamorphosis Stages)			
				Elvers	
Preleptocephal	Leptocephalus Stage I.	Semilarva II.—III.	Hemilarva *IV.*—*V.* A.	unpigmented *V.* B.—*VI.* A.	pigmented *VI.* B.
Pelagic Stages				Bottom Stages	

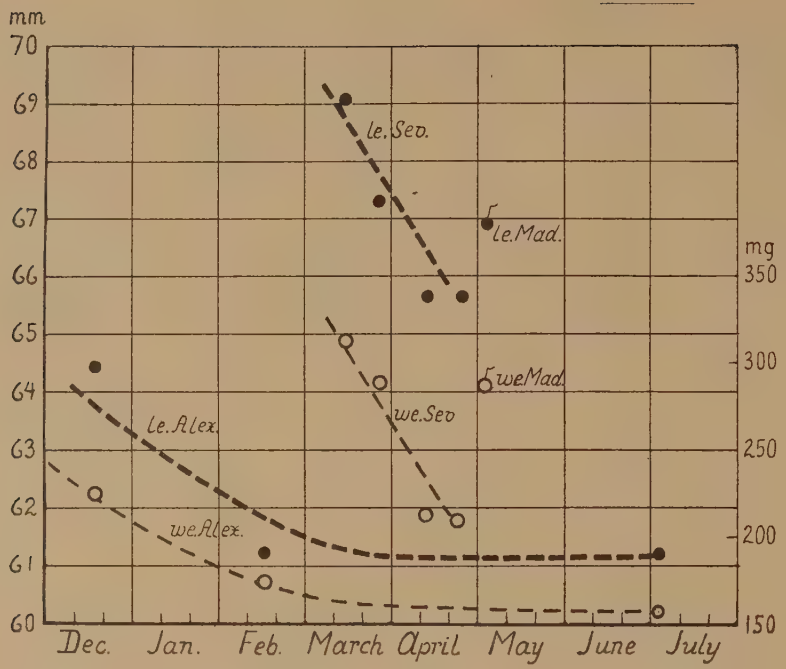

Fig. 6. Length and weight of elvers. Mouth of Nile (Alex.); season $19^{19}/_{20}$ Febr. and July samples, season $19^{20}/_{21}$ December sample. Severn (Sev.), and Madeira (Mad.), season $19^{20}/_{21}$. Stage V.B.—VI.A. II. 1 & 2. Original measurements.

The Livorno elvers, again, are also somewhat smaller in point of length than the samples taken at about the same time (Stages V. B. VI. A. I) in the North Sea, but the weight, on the other hand, is higher in proportion.

Figs. 8 and 9, covering all available observations compared from a series of different seasons, confirm the view that the elvers of the Nile are the smallest hitherto known. For the rest, there appears to be a characteristic difference in the elvers from the three areas concerned. In point of length, the North Sea and Atlantic elvers for the same months, apart from annual variation, appear to agree well enough, while the Mediterranean samples seem essentially smaller.

In point of weight, the position is different; the Atlantic elvers are the heaviest, both absolutely and relatively heavier than those of the North Sea, while the Mediterranean elvers, apart from the Nile samples, are also relatively heavy.

The elvers from all three areas, however, will of course belong in any case to one and the same stock, which, as we know from the definite results of Johs. Schmidt's investigations, were all hatched out on the spawning grounds in the western Atlantic and moved thence eastward towards Europe. Sooner or later, in the course of this eastward migration, the hosts of larva divide into two groups, one continuing its way to the north-east, and, after completion of metamorphosis, appearing as elvers in western and northern Europe, the Atlantic elvers (including those of the North Sea), while the other moves more to the eastward and passes throug the Straits of Gibraltar into the Mediterranean, undergoing metamorphosis here, and giving us the elvers of the Mediterranean.

The distinction between the two is of course not very sharply defined, and the facts as noted apply only to the main bulk of the larvæ, as distributed between the two areas.

The apparently characteristic differences in point of size between the two groups of elvers can thus only be due to difference in the hydrographical

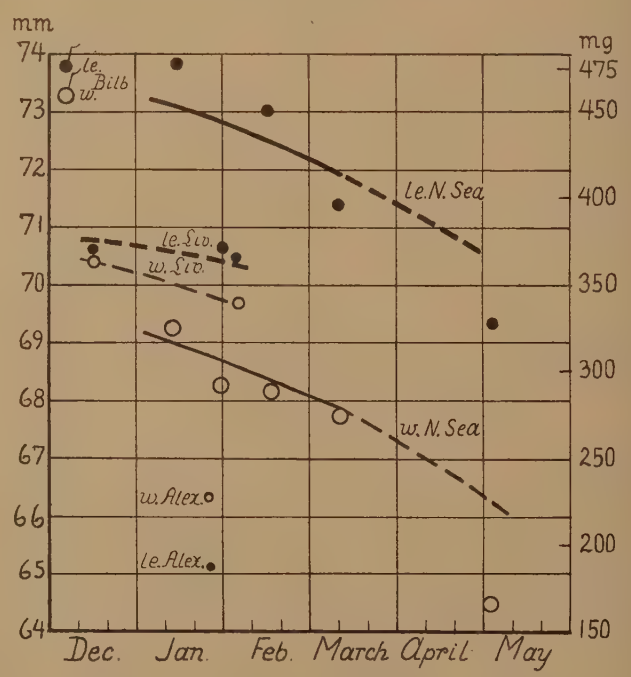

Fig. 7. Length and weight of elvers. Season $19^{22}/_{23}$. Mouth of Nile (Alex.), Calambrone (Liv.), Northcoast of Spain (Bilb.) and North Sea (N. Sea). All North sea samples taken out at sea, on or near to bottom, the remainder in fresh water. Stages V. B.—VI. A. II 1 & 2. Sample from Bilbao measured by Dr. Hornyold, the remainder original.

conditions of the areas where the last part of the larval existence, and the period of metamorphosis, are passed.

In this connection, it seems natural to regard the inferior weight of the North Sea elvers, compared with those of the samples from Western Europe, as due to their longer migration in the pelagic or semi-pelagic stages.

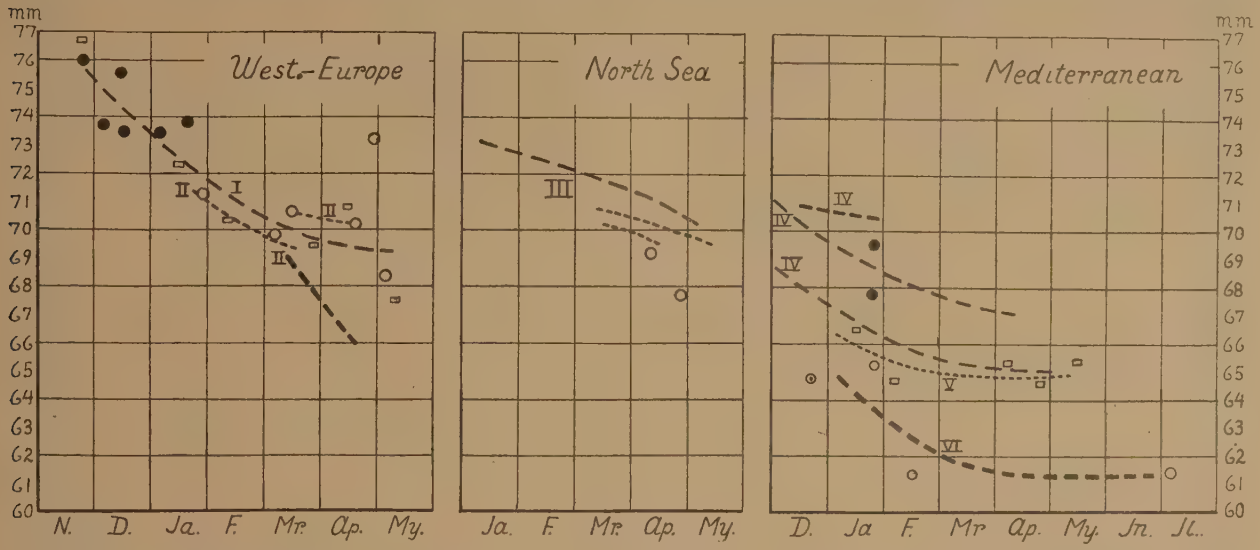

Fig. 8. Length of elvers from the western Europe, North Sea and Mediterranean shores. Curve I based upon Dr. Hornyold's measurements from Bilbao ($19^{22}/_{23}$) and Santander ($19^{17}/_{18}$ □), supplemented by original samples (●) from Santander and San Sebastian ($19^{05}/_{06}$). Curves II based upon samples from S. W. Ireland and Severn, $19^{05}/_{06}$ (orig.), 1911 (Lübbert), and $19^{20}/_{21}$ (orig.). Curves III based upon 1905, 06 and 1923-material, pelagic and fresh water samples (orig.), supplemented by single samples (o) 1907 & 1910. Curve IV: Livorno and Arno Material, Grassi's and original, 1912—1923, supplemented by original samples (●) 1911. Curve V represents Hornyold, samples from the Balearic Isl. (□ 1918—19), Curve VI Alexandria samples 1919—23, orig.

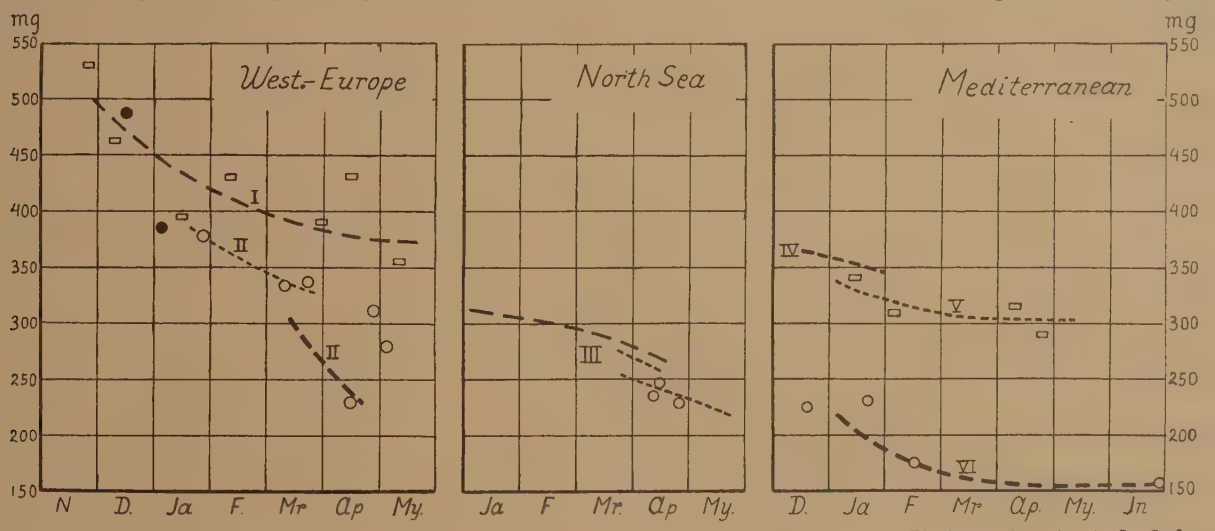

Fig. 9. Weight of elvers from the Western Europe, North Sea and Mediterranean shores. Cf. also explanation to fig. 8 above.

The inferior length, but proportionately greater weight, of the Mediterranean elvers in the western basins might be taken as due to the higher temperature in these waters. This might either occasion a more pronounced reduction in Stages II—IV, or the larvæ might become fully-grown, i. e. ready for metamorphosis, at a somewhat earlier age, i. e. somewhat smaller size, than in the Atlantic. And in either case, the last pelagic stages in the western part of this water would be of relatively short duration. The very small

size of the Nile elvers, and especially their very slight weight, support this view, as the last pelagic stages of this group must presumably have covered a long distance through the warmest parts of the Mediterranean.

Whether the differences noted will prove to be constant throughout a longer period is not certain, but systematic investigations in the future would provide better material for determination of the length-weight proportion in each area, eliminating the annual variations, than that we have at present.

C) Various observers have noted, both in the Mediterranean and in western European waters, a decrease in size of the elvers at the same stage in the course of the season[1], not to be confused with the reduction in size from Stage V. B. to VI. A. II, which is a consequence of metamorphosis, and has been followed for instance in aquarium experiments.

This decrease in the size of the elvers for instance for Stages VI. A. I. and A. II. amounted in several instances to at least 5—6 mm. and 70 mg. in the course of the season. The point was noted more or less distinctly at various localities in the north and south of Europe and in different years, so that there can hardly be any doubt as to its constant and general character.

The factors which determine the size of the elvers (we are here only referring to the youngest stages, V. B. VI. A, I) at a given time must be partly the size of the corresponding fully-grown larva, i. e. ready for metamorphosis, and partly the reduction in length and weight which these pelagic metamorphosis stages undergo. A decrease in the average size of the elvers in the course of the season must therefore be traced back to corresponding alterations in one or both of these factors.

Presuming the average size of fully-grown larvæ of the same year-class to be the same for the oldest as for the younger and youngest, and that both older and younger ones, regarded as age-groups, move at the same average rate of speed to the eastward, then the corresponding mass of elvers arriving month by month throughout the season would show the same size. Only with an essential rise of temperature and consequent more marked reduction in course of the period when metamorphosis stages occur, or if growing larvæ of the same age were "sorted out" in the course of their eastward migration, so as to bring the largest specimens nearest land, while the others were still farther out, could we expect to find a decrease in the size of the elvers at their ascent. There may perhaps be some such alteration in temperature as here suggested, but hardly of sufficient importance. The principal cause of the phenomenon would then appear to be that the more rapidly growing individuals displayed greater activity in the course of their migration. If this were so, then in the course of the various month-classes' movement across the Atlantic, the largest in each group would get ahead of the others of same age, and we should have a mingling of larger and smaller individuals from the various month-classes, and a sorting out, so that the advance guard would consist of the oldest and largest, the rearguard of the youngest and smallest, while the main body was composed of a mixed contingent of larger and smaller, younger and older ones.

Whether this theory is correct must be left for the future to decide. I am indebted to Dr. Johs. Schmidt for calling my attention to the possibility, and certainly seems a reasonable supposition enough.

It was presumed in the foregoing that the average rate of growth was uniform for all larvæ, both those hatched out earlier and those of later appearance. This, however, is hardly certain; it might be, for instance, that the oldest larvæ, hatched out already in February/March were from that very fact endowed with better conditions for growth during their first 7—8 months of life than the somewhat younger ones, so that the oldest larvæ would get a start in the race of growth ahead of the younger. But even if no dimensional difference *ab ovo* exists between larvæ or earlier and later spawning, as observed in several coastal forms, a difference in the rate of growth at the beginning and end of the season would also tend towards the same ultimate result, viz. a decrease in the size of the elvers appearing on our shores, and this more particularly if any sorting out of the larvæ in point of size actually took place in the course of their eastward movement.

[1] The fact is also well known to professional fishermen engaged in the elver fisheries of western Europe.

D) The economical interest attaching to the ascent of the elvers in European water is considerable. This applies, whether the elvers are captured for consumption as such, or for purposes of transplantation, or left to themselves to find their way up into the coastal or inland waters where they are later fished for as eels. It is thus the more surprising that no attempt has been made, save in a very few places, to procure statistics for the purpose of estimating the extent of the elver movement on the spot and following its fluctuations from year to year. In a country like Denmark, where the eel fishery has from early times played an important part, amounting to $^1/_3$—$^1/_5$ of the total yield of the fisheries, such statistics are entirely lacking, and we are thus unable to determine what effect the greater or smaller extent of the elver immigration in separate years may have upon the relatively wide fluctuations in the yield of the eel fishery. The elvers are not fished for in this country, and have up to now only been utilised to a very limited extent as material for transplantation. But with the increasing exploitation of our rivers and streams for water-power, hindering or often altogether precluding the passage of the elvers up into the inland waters, the need for adequate measures must soon be realised. It is therefore, in my judgement, essential that observation posts should be established both on the coast and inland, where notes could be taken each season as to the time and extent of the elvers immigration, possible influence of external conditions, etc. If such an observation system[1] could be established not only in Denmark but also in other European countries. where the eel is in any way of value, we should certainly at the same time collect information of purely scientific interest in the further study of the detailed life history of the eel.

SUMMARY

1. The material available for determining the size and weight of the elvers arriving on the shores of North and Western Europe, as also in the Mediterranean, consisted of the following:

a) Three series of samples of elvers, from the Nile Delta, seasons $19^{19}/_{20}$, $^{20}/_{21}$ and $^{22}/_{23}$, from the mouth of the Arno, season $19^{22}/_{23}$ and from the Severn (Epney), season $19^{21}/_{22}$, taken at various times during the respective seasons.

b) A series of samples of elvers from the North Sea, season $19^{22}/_{23}$, also some few pelagic samples of earlier date.

c) Several isolated samples from $19^{20}/_{21}$ and earlier years, being elvers taken chiefly in the fresh waters of north and western Europe.

Practically all samples were fixed in formol. The specimens were measured and weighed, and their degree of pigmentation (Stage) determined.

2. The samples for seasons $19^{19}/_{20}$, $^{20}/_{21}$ and $^{22}/_{23}$ showed the following sizes (average length in mm. and do. weight in mg.).

	Season $19^{19}/_{20}$		Season $19^{20}/_{21}$				Season $19^{22}/_{23}$					
	Febr.	July	Dec.	March	April	May	Oct.	Dec.	January	Febr.	March	May
North Sea & Kattegat....									**73.9 70.6** 324 292	**73.1** 285	**71.4** 277	**69.2** 170
Epney on Severn (West of England).....				**69.0 67.3** 313 284	**65.6 65.7** 214 210			÷				
Madeira						**66.9** 280						
Mouth of the Arno (Livorno).....								**70.6** 369		**70.5** 340		
Nile Delta	**61.7** 175	**61.6** 150	**65.3** 225						**65.1** 226			

[1] Possibly combined with systematic pelagic fishery during period of metamorphosis.

3. The ascent of the elvers in Europe and the countries south of the Mediterranean must be regarded as a whole, as the conclusion of the pelagic larval life of the eel, which lasts for some years, from its commencement in the central Atlantic to its last stages, which are only reached when the larvæ in the course of their eastward movement have crossed to the western side of the continental slope in the Atlantic, and, in some cases, into the Mediterranean.

a) In the season $19^{22}/_{23}$ (see fig. 5) the ascent began in October—November—December in the Mediterranean (Nile and Arno) and in Western Europe (Santander) while at the same time, great hosts of apparently corresponding stages had arrived in the North Sea and the Skagerak, but did not commence their ascent into fresh water until warm weather set in with April and May.

In other seasons, the position may be different, from the mere fact that the eastern limit of occurrence for the grown larvæ may be differently situated from year to year. As a rule, however, the ascent will have commenced on a large scale in December January in southern and western Europe, but not until 2—3 months later in the North Sea countries. In some years, the ascent is retarded chiefly on account of the lower spring temperature here, while in others it may perhaps be also delayed by later arrival of the metamorphosis stages in these waters. The season lasts several months, but its course is often irregular; great hosts may arrive at longer or shorter intervals. Quite occasionally, elvers have been noted in several places as arriving throughout the greater part of the year.

b) The size of the elvers on the North Sea coasts, in western Europe and in the Mediterranean, is shown graphically in fig. 6—9, based on all available suitable material of elvers at the same stages.

Fig. 7 show samples of the same stage from one and the same season of ascent.

Taken as a whole, the various figures show the following:

1) According to length, the North Sea and Atlantic elvers agree, save for the annual variation. The Mediterranean elvers are essentially smaller (in some years, however, only a little smaller).
2) According to weight, the Atlantic elvers are heavier than those of the North Sea, while the Mediterranean elvers are also comparatively heavy.

As the elvers in any case form parts of one and the same stock having a common origin, these differences must be due exclusively to difference in the hydrographical conditions of the waters where the last part of the larval life and the metamorphosis period are passed.

The inferior weight of the North Sea elvers, compared with that of the western European samples, might then be ascribed to the longer journey made by the last pelagic or semi-pelagic stages here.

The inferior average length of the Mediterranean elvers, which nevertheless, save in the eastern areas, show comparatively high values for weight, might be taken as due to the high temperature during metamorphosis, with marked reduction at stages II—IV, in connection with the fact that the latest pelagic stages in the western part of this area will as a rule be of relatively short duration.

In the eastern waters, the position is different, and correspondingly, we find in some of the Nile samples the lowest values hitherto recorded for length and weight of the elvers within the area of distribution of *Anguilla vulgaris*.

c) The series of samples show in several instances a distinct decrease in size of the elvers at the same stage throughout the course of one and the same season. This has been noted both for Mediterranean elvers, and for elvers and pelagic glass-eels from western Europe and the North Sea.

This decrease in size, which must not be confused with the reduction from Stage V. B.—VI. A. IV. due to metamorphosis, may be explained by supposing that the largest, rapidly growing larvæ move on the average faster than the smaller ones, so that the elvers first arriving will be the largest. Another factor may perhaps be that the larvæ earliest hatched would have better possibilities of development than those hatched out later.

4. It is recommended that systematic observation of the elvers and their ascent should be made, and statistics procured.

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5.

Experiments with drift-bottles
(Second Report).

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Published December 31, 1923.

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I. INTRODUCTION.

The Leader of the Danish Oceanographical Expeditions to the Mediterranean and adjacent seas, Dr. Johs. Schmidt, has kindly invited me to work out the data referring to the drifts of the current-bottles which had been set adrift in the Western Mediterranean by captains of vessels of various Steamship Companies.

The history of earlier investigations with drift-bottles in the Mediterranean, the arrangement and method of these Danish experiments and the data of the first six, with general remarks and discussion of the results obtained, have been published by Dr. Schmidt in his first report (vol. III, No. 1, of this Report). The experiments already published refer to the 57 bottles recovered out of the 200 set adrift from January up to August 1st, 1912.

The present second report refers to the other 135 bottles recovered out of the 515 set adrift from August 7th, 1912 up to July 5th 1913.

I have here to express my heartfelt thanks to Dr. Schmidt, for kindly entrusting to me his interesting material, and to Dr. Francesco Musella, Assistant in the R. Istituto Superiore Navale in Naples, who has given valuable assistance in the determination of the geographical positions on the charts[1].

II. PARTICULARS OF THE EXPERIMENTS.

Before passing to the account of the new experiments I must mention that, since the publication of Dr. Schmidt's report, information has been received as to two further bottles, Nos. 641 and 648, belonging to Experiment No. 5. On August 1st 1912, 25 bottles were set adrift near Cape de Gata (36° 40′ N., 1° 59′ W.), and of these, 8 had been found up to the publication of the first report. We have now to add:

No. 641, found in the Golfe de Gabès, on June 4th 1914, by El Aroussi Charad, Maître de port à Sfax, Tunisie;

No. 648, found at Oliveri (Sicily, prov. of Messina) on July 4th, 1913, by Giovanni De Natale, of Oliveri.

The bottle No. 641 has thus covered 860 miles in 672 days, at a speed of at least 1,3 miles per diem; but since it followed, at the beginning, the same route as Nos. 642 and 644, whose average rate worked out respectively at 3,3 and 4,5 miles per diem, we may doubtless assume that it was not found until many weeks after being washed ashore.

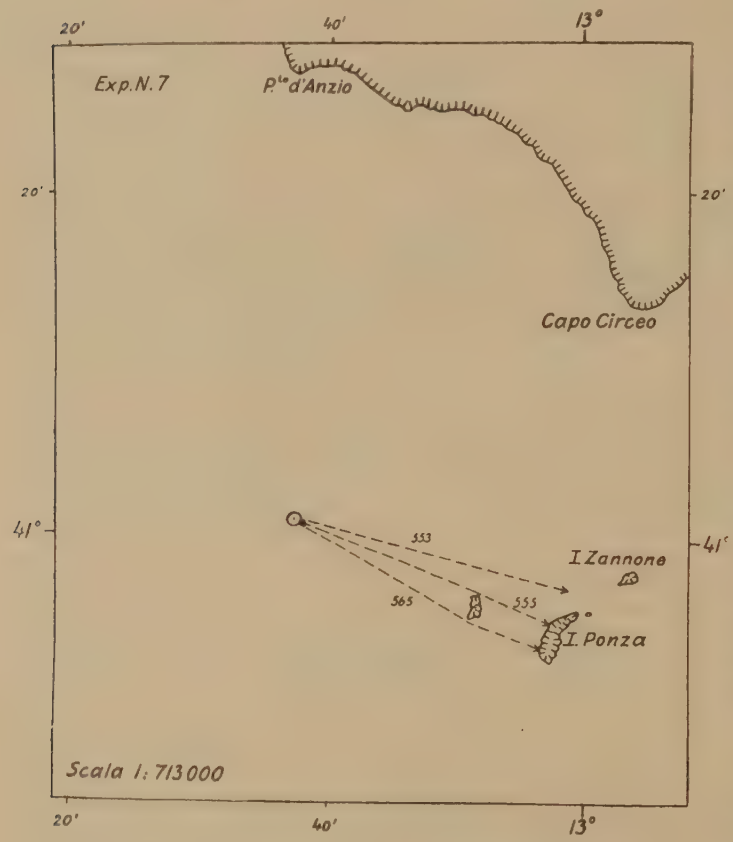
[1] To mark the routes, the places of liberation and the places of recovery of the bottles, we have employed charts Nos. 61, 137, 209 *a*, 209 *b* and 286 of the R. Istituto Idrografico Italiano in Genoa.

The bottle No. 648 has covered 820 miles in 347 days, travelling at something over 2,4 miles per diem, thus proving that the movement of the water on the north coast of Sicily is apparently from West to East, contrarily to the opinion of some authors.

I give here an account of the new experiments, beginning from No. 7, the last experiment in Dr. SCHMIDT's report being No. 6.

Experiment No. 7.

Out of the 25 bottles set adrift on August 7th 1912, at noon, in the Tyrrhenian sea, 16 miles from Ponza Island (41° 1′ N., 12° 38′ E.) from the Danish M. S. "Selandia", Captain Gabe, 5 were recovered, i. e. 20 %. All the bottles were found at or near Ponza Island, three on the day of liberation.



The movement of the water was therefore, that day, towards E. S. E., and the velocity must have been exceptionally great, as we may suppose that the 3 bottles were found before sunset, and therefore apparently covered 16 miles in about eight hours.

Experiment No. 8.

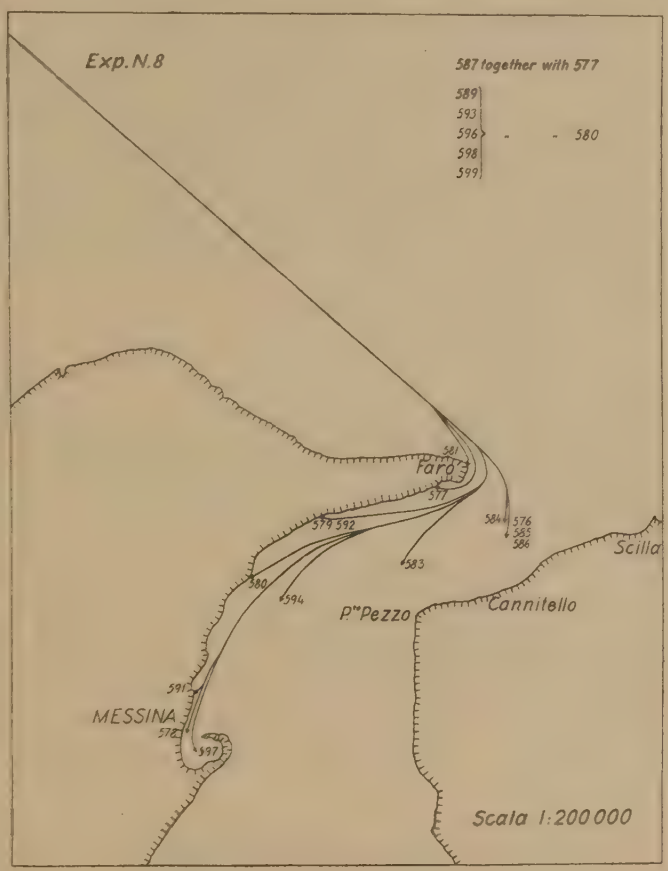
Of the 25 bottles set adrift on August 8th 1912 in the Tyrrhenian, at abt. 16 miles N. W. of the Strait of Messina, from the Danish M. S. "Selandia", information has been received of about 20 bottles, or 80 %. This exceptionally high percentage of bottles recovered is due to the fact that the coast of Sicily, in the neighbourhood of Messina is densely populated. Of the bottles found, 7 were washed ashore on the coast of Sicily, from Faro to Messina, and 13 picked up floating in the middle of the Strait or near the shore.

The currents in this Strait are tidal streams alternating every 6 lunar hours. When the moon passes the meridian, the stream in the channel runs southward; six lunar hours later the current is running north; near the coasts there are counter-currents and eddies. These alternate streams, whose courses have been studied and are well known, are due mainly to the differences in the relative water-level of the Tyrrhenian and Ionian seas, as high water in one of them takes place at the time of low water in the other. The greatest velocity, which may amount to 5 miles per hour, occurs during the days of full and change. The configuration of the shore-lines and of the sea-floor in the channel, complicates the phenomena, and again the meteorological conditions, wind, etc. may occasionally modify the expected theoretical velocity.

On August 8th, 1912, at the hour of liberation of the bottles, the current in the Strait was setting south, as the transit of the moon, on this day, was at 7½ a. m. The N. W. wind, 4 Beaufort, and N. W. sea. 3, aided the drift of bottles towards S. E., so that on the same day (August 8th) the bottle No. 581 covered abt. 16 miles to Cape Peloro. Presuming that the bottles drifted to the north part of the Strait in 12 or 14 hours, the tidal current would then be setting southward again, and carry the bottles into the

channel. The next north-going current would have washed up some of the bottles on the Sicilian coast, especially in the place where the shore-line turns decidedly toward the East.

The bottle No. 593, found stranded, on the morning of August 9th, seems to indicate a great velocity, nearly 18 miles per diem. The bottles found floating on August 9th (No. 576, 580, 583, 584, 585, 586, 599) also show great velocities, from 12 to 21 miles per diem; but these velocities are probably lower than the real ones, as the alternate tide-currents may have drifted the bottles southwards and northwards successively; this is still more likely in the case of the bottles (Nos. 578, 589, 594, 596, 597, 598) found floating on August 10th, their apparent rate of drift being from 11 to 16 miles per diem. The other bottles washed ashore (Nos. 577, 579, 587, 591, 592) all show a minimum velocity of 12 miles per diem.



Experiment No. 9.

Out of the 25 bottles set adrift during the night of December 9th 1912, in the Balearic sea, from the German S. S. "Göben", Captain Ad. Ahlborn, 6 were found (i. e. 24 %); three landed on the coasts of Algeria, Tunis and Tripoli, two in Sicily and one in Spain. All the bottles probably followed the inflowing Atlantic water along the north coast of Africa, drifting towards the East, notwithstanding the S. E. wind, Beaufort 3, which was blowing at time of liberation.

The 2 bottles (No. 661 and 671) found floating, the first along the west coast of Sicily, the second along the coast of Algeria, both indicate a low velocity, abt. 1.5 miles per diem; a greater velocity is shown by No. 655, which came ashore near Trapani (Sicily). Assuming that No. 673 reached the N. E. coast of Spain, not directly, but following at first the route of No. 655 and 661, and then drifting close to the west coast of Italy and gradually turning towards W. and S. W., according to the supposed cyclonic circulation of waters in the Tyrrhenian, we obtain, also for this bottle, a moderate rate of drift, less than 5 miles per diem.

Experiment No. 10.

Of the 25 bottles thrown out on the same day, December 9, from the same ship, between the Balearic Islands and the north coast of Africa, (38° 15′ N., 4° 10′ E.), 6 were found: two in Minorca, two in Sardinia, one in Tunis and one in Spain. This last (No. 690) found floating near Valencia, probably followed at first the same route as the two (N. 680 and 695) making for Minorca, and then turned N. W., W., S. W., as far as the Spanish coast, with an average velocity of 1.3 miles per diem. The other bottle found floating on the north side of Minorca, indicates a velocity of 2.7 miles. Only one (N. 699) followed the eastward route close to the north coast of Africa.

Experiment No. 11.

Of the 25 bottles thrown overboard further on (38° 50′ N., 4° 36′ E.), later in the same day, 9 were recovered, or 36 %. Assuming that they followed the shortest route, three of them (No. 710, 714, 724) drifted westward, one (720) towards N. N. W., four (N. 706, 715, 717, 722) towards E., and one (No. 712) towards S. E. None was found floating, but the minimum velocity was greater (2,2 to 5 miles per diem) for the bottles going eastward. The one (No. 714) recovered on the S. E. coast of Spain had a minimum rate of drift of 3,4 miles supposing that it followed the shortest route.

Experiment No. 12.

Of the 25 bottles set adrift on the same day, further on (39° 30′ N., 5° 3′ E.), 8 were found (or 32 %). Taking the shortest route, the two bottles (No. 728 and 732) which drifted towards N. W., would have a minimum velocity of 0,5 and 0,8 miles per diem, that towards N. E. (N. 740) and all the others (No. 738, 741, 742, 744, 745) moving at first towards E., indicate a greater minimum velocity (2,6 to 4,5 miles). I presume that the bottle N. 742, found floating near the west coast of Central Italy, must have drifted, at first, together with No. 741, towards E. along the north coast of Sicily, and then turned to N. and N. W. close to the coast of the Italian Peninsula, having an average rate of drift of 6,2 miles per diem.

Experiment No. 13.

Of the 70 bottles set adrift on January 24, 1913, in the westernmost part of the Alboran Sea (35° 53′ N., 2° 42′ W.), from the Danish S. S. "Chr. Broberg", only 13 were recovered (i. e. nearly 19 %). Ten of them came ashore on the north coast of Africa and the east coast of Tunis, one in Majorca and one in Sardinia. The minimum rate of drift was from 8 to 13 miles per diem for the bottles on the north coast of Africa and nearly 7 miles for the bottles found in Tunis. One of them (No. 758) drifted towards S. E. and was found floating, showing a lower velocity, 4,2 miles per diem.

Experiment No. 14.

Of the 10 bottles thrown out from the same ship "Chr. Broberg" on January 30, 1913, in the S. W. part of the Tyrrhenian Sea (38° 0′ N., 10° 16′ E.), 3 were recovered: two on the east coast of Tunis, and one (No. 778), on the west coast of Central Italy. The velocity of the latter (4.5 miles per diem supposing the route to be as shown in the chart), may have been greater if we imagine the route closer to the north coast of Sicily and the west coast of Italy.

Experiment No. 15.

Of the 15 bottles set adrift on the same day, at 27 miles E. of the S. E. coast of Sardinia (39° 0′ N., 10° 8′ E.), 6 were recovered (i. e. 40 %): two drifted towards W. and landed in Sardinia, one towards E. was found on the west coast of South Italy, two towards S. S. E. reached the east coast of Tunis, and one towards S. W. as far as the north coast of Tunis. Their minimum velocity was from 2.5 to 5.6 miles per diem.

Experiment No. 16.

Of the 200 bottles set adrift on February 22, 1913, from the Danish S. S. "Pangan", in the westmost part of the Alboran Sea (36° 5′ N., 4° 40′ W.), 31 have been recovered (i. e. 15.5 %), of which 8 on the coast of Spain, two in the Balearic Islands, 13 on the coast of Morocco, 7 on the coasts of North Africa and one near Cette, in France. As to the latter, it is difficult to state whether it drifted close to the coast of Spain, towards N. and N. E., or if it proceeded at first towards E., then passing close to the west coasts of Sardinia and Corsica and finally turning towards N. W. and W., as indicated on the chart.

It is noticeable that the minimum velocity of the bottles found in Spain and in Morocco was very low, from 1 to 2 miles per diem, also that of No. 1007 found floating at Ceuta; rather greater that of No. 1009 found floating near the coast in Morocco (4.4 miles). The minimum rate of drift of the bottles found in the Balearic Islands was 3.1 and 3.6 miles; and still greater (maximum 12.2 miles) that of the bottles going towards East.

Experiment No. 17.

Of the 15 bottles set adrift on February 22th, 1913, from the Danish S. S. "Chr. Broberg", at 5½ miles from Cape Gallo (Sicily) only one was recovered, the same day, not far from the spot of liberation. It was probably driven by the wind (N. N. E., 5 Beaufort) especially since it was without sand ballast.

Experiment No. 18.

Of the 15 bottles set adrift on February 23, from the Danish S. S. "Chr. Broberg" in the S. W. side of Tyrrhenian Sea (38° 18′ N., 10° 34′ E.), 6 were found (thus 40 %) of which three went towards S. S. E. and landed on the coast of Tunis, and three towards E., one coming ashore on the north coast of Sicily and two in Calabria, near the Strait of Messina. Perhaps the wind (N., 6) and the sea (N., 6) determined the drift of the first 3, which were washed ashore on the coasts of Tunis. All the bottles were without sand ballast.

Experiment No. 19.

Of the 35 bottles thrown overboard on July 5, 1913, from the Danish S. S. "Pangan" Captain Chr. Schmith, in the Balearic Sea (38° 43′ N., 0° 40′ E.), 19 were recovered (or 54 %) the majority (14) on the coast of Spain, showing a current towards N., two on the coast of France, one in Minorca, one in Tunis, and one floating in the Strait of Messina. The rate of drift of the bottles washed up on the coast of Spain was very low, the highest figure being 3.2, with the exception of No. 1084 found near Barcelona, which was perhaps found floating, and shows a velocity of 6.8 miles per diem. If No. 1098 was also found floating, its velocity (1.9 miles) being very slight, seems to show that the shortest distance is not right. The probable route of No. 1114, found floating in the Strait of Messina, suggests a current towards E. on the north coast of Sicily.

III. DISCUSSION OF RESULTS.

The first series of Danish experiments, which are discussed by Dr. Johs. Schmidt in the first report, deal with the east-going current along the north coast of Africa, and the movement of the waters along the east-coast of Spain. The latter seems to be, during summer, from south to north in the region between the Balearic Isles and Spain; in winter the winds blow strongly from N. W. and may set up a contrary movement.

In the first experiments, the bottles were liberated only in the Alboran Sea; in the present series however, bottles were set adrift also in the Balearic and Tyrrhenian Seas.

It is therefore preferable to consider the experiments separately, according to site of liberation:

in the Alboran Sea (exp. No. 13 and 16)
in the Balearic Sea (exp. No. 19, 9, 10, 11 and 12)
in the Tyrrhenian Sea (exp. No. 14, 18, 15, 7 and 8).

The drift is throughout noted on the charts as direct, with the exception of two or three occasions, particulars of which are given in the following.

In the first of the two experiments made in the Alboran Sea (exp. No. 13) we have seen that the bottles, thrown out in January, went towards the east, and were nearly all recovered on the coast of north Africa. The average velocity was comparatively high, reaching 12.5 miles per diem, this being a minimum velocity, as the bottles were found on the shore. The one (No. 758) found floating, at no great distance from the site of liberation, shows a rather low velocity, nearly 5 miles per diem. In this experiment, two bottles, after a drift towards the east, turned towards N. E.: one landed in Majorea, and the other in Sardinia, their velocity being abt. 8 miles per diem.

In experiment No. 16 the bottles were liberated in the western part of the Alboran Sea, also during the winter (February 22); of the 31 bottles recovered, 8 landed on the south coast of Spain, showing a low velocity, not over 2 miles per day; 14 landed on the coasts of Morocco, also with low rate of drift (2.3 miles per diem No. 961) and 6 followed the east-going current off north Africa, at a higher velocity (12.2 miles per diem, No. 951). The two bottles found in the Balearic Isles show a velocity of 3.1 and 3.6 miles per diem. As to the bottle N. 962, found near Cette, I suppose that for the first few days it went towards E., together with other bottles, and then turned towards N. E. and N., following the west coast of Sardinia. In this experiment, the bottles found on the coasts of Granada and Morocco, further W. from site of liberation, seem to indicate some coastal movement towards W. of the water close to these coasts, as stated also by Dr. Schmidt (1st report, p. 10, note).

In experiment No. 19, the bottles liberated in July, between the Balearic Isles and Spain, were nearly all found on the east coast of Spain, and with the exception of one (No. 1084), all show a low velocity, from 1 to 3 miles per diem, also No. 1098 (1.9 miles per diem) which was found floating. The velocity of No. 1084, which landed further to the north, in Spain, was 6.8 miles per diem. The two bottles recovered on the coast of France, if they did not make great detours, also show a low rate of drift (2.7 miles per diem). Only two of the bottles went towards the E., one reaching the coast of Tunis, the other the Strait of Messina. The average velocity of the latter, found floating, was 3 miles per diem.

Regarding the other experiments in the Balearic Sea, the following may be noted:

In experiment No. 9, three bottles were found on the coasts of Africa, one in Spain, and two in Sicily. As to the last two, it is to be observed that, while bottle No. 655, found on the shore at Trapani, shows a minimum velocity of 5.3 miles per diem, No. 661, found floating further eastward, at Termini, shows an average rate of drift of 1.6 miles: we may suppose that this bottle has occasionally undergone some backward movement close to the north coast of Sicily. I have supposed that bottle No. 673 drifted at first eastward, with other bottles, and then turned to N., NE., etc., following the cyclonic movements of waters in Tyrrhenian Sea, which was stated by Admiral Smyth and confirmed as existing during winter by many Italian experiments.

The bottles of experiments No. 10, 11 and 12, liberated further to the north, were dispersed in various directions, showing generally low velocities, the maximum (6.2 miles per diem) being that of No. 742, found floating on the west coast of Central Italy, for which I assume the drift noted on the chart.

Experiments No. 14, 18 and 15 refer to bottles liberated in the Tyrrhenian Sea, during the winter, and show a dispersal of the bottles in various directions, but especially towards the east, following the north coast of Sicily, and southwards to the coasts of Tunis. The velocities were between 1.6 and 5.6. Bottle No. 778 reached the west coast of Central Italy, probably following the north coast of Sicily. In experiment No. 15, the bottles were set adrift abt. 30 miles eastward from the south-east coast of Sardinia, and two bottles went westward and landed on this island, showing a minimum velocity of 3 and 4 miles per diem.

In experiment No. 7, all the bottles drifted towards Ponza Islands, and three of them were found

on day of liberation; they had thus drifted for abt. 17 miles before sunset, going towards the S. E. with great velocity.

The particulars of experiment No. 8, when the bottles were set adrift not far from the Strait of Messina, have been described, and confirm the high velocities of the currents in this Strait.

From these results we may draw the conclusion that in the western Mediterranean, the movements of the waters do not constitute true currents, but are influenced by the prevailing winds.

During the winter, depressions are frequent and the movement of the waters is cyclonic; during the summer high pressures prevail, and these conditions may produce an inversion of the currents, as Dr. SCHMIDT observes for the east coast of Spain and as confirmed by these experiments.

Prof. OLINTO MARINELLI and his colleagues, in their study of the currents along the west coast of the Italian Peninsula were led to the same conclusion.

The east-going current off north Africa, the causes of which have been studied in these Reports by Dr. NIELSEN, is too strong to be inverted by contrary winds, as these Danish experiments confirm. Its velocity, which at times reaches 20 miles per diem (Dr. SCHMIDT) can be reduced by easterly winds; but this current, and also its less rapid branches, such as that off the north coast of Sicily, may be considered as true currents, running always in the same direction.

Experiment No. 7

Bottles No. 551—574,
thrown out from m/s "Selandia".

Liberation: Position 41° 1′ N., 12° 38′ E. Date 7. August 1912; 12⁰⁰ m. Wind S. 3. Sea S. 3.

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
552	A 2 km da Ponza, versante Nord	40°57′ N. 12°59′ E.	7. Aug. 1912	16·6	—	—	Rosalia Romano di Antonio, Isola di Ponza	
555	Isola di Ponza, borgata Forni, spiaggia della Cicata	40°55′ N. 12°58′ E.	9. Aug. 1912 11⁰⁰ a. m.	17	2	8·5	Antonio Conte, fu Pietro, Isola di Ponza	
556	Isola di Ponza	40°55′ N. 12°58′ E.	7. Aug. 1912	—	—	—	Silverio Vitiello di Gaetano, Isola di Ponza	
565	Nella spiaggia di Chiardiluna, Isola di Ponza	40°54′ N. 12°57′ E.	10. Aug. 1912	16·2	3	5·4	Michele Migliaccio, di Silverio, strada Chiardiluna, Isola di Ponza	
568	Isola di Ponza	40°55′ N. 12°58′ E.	7. Aug. 1912	—	—	—	Silverio Vitiello di Gaetano, Isola di Ponza	

Experiment No. 8

Bottles No. 576—600,
thrown out from m/s "Selandia"
(No. 588—600 with sand ballast)

Liberation: Position 38° 33′ N., 15° 24′ E. Date 8. August 1912, 6⁰⁵ a. m. Wind NW 4. Sea NW 3.

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
576	Nello Stretto di Messina, all'imboccatura del Faro, in mezzo al Canale	38°15′ N. 15°40′ E.	9. Aug. 1912 14²⁰	18	1·3	13·8	Giuseppe e Pasquale Ingegneri, Torre di Faro, Messina	Floating
577	Torre di Faro, Stretto di Messina	38°14′ N. 15°38′,₅ E.	9. Aug. 1912 18⁰⁰	18	1·5	12·0	Bancia Mario, S. Capo Elettricista, R. Stazione Fotoelettrica, Messina	
578	A 50 braccia dalla spiaggia, all'imboccatura del porto di Messina, galleggiante	38°12′ N. 15°34′ E.	10. Aug. 1912 5⁰⁰ a. m.	24	2	12·0	Diego Capillo, marinaio di barca, Ganzirri (Messina)	Floating
579	Nello Stretto di Messina, presso Ganzirri	38°15′ N. 15°36′,₅ E.	9. Aug. 1912 20⁰⁰	20	1·6	12·5	Giuseppe Arena di Nicolo, via Mangraviti, 305 Ganzirri (Messina)	
580	*A 200 m dalla spiaggia di Guardia, alla Pace* (Messina)	38°15′ N. 15°35′ E.	9. Aug. 1912 *6⁰⁰ a. m.*	21	1	21	Giov. Batt. La Fauci, fu Paolo, Villaggio Pace (Messina)	The data in italics were obtained by correspond.
581	Arenata presso la punta di Capo Peloro, vicino il Faro omonimo (Stretto di Messina)	38°16′ N. 15°89′,₅ E.	8. Aug. 1912	16·5	—	—	Ragioniere Piccione Giuseppe Emilio, Lanterna di S. Ranieri, Messina	
583	In mezzo allo Stretto di Messina, fra Ganzirri e Cannitello	38°14′,5 N. 15°38′ E.	9. Aug. 1912 12⁰⁰	19·5	1·25	15·6	Rando Francesco, fu Nicolo, pescatore, Ganzirri (Messina)	Floating
584	Fra Scilla e Cariddi	38°15′ N. 15°40′ E.	9. Aug. 1912 15⁰⁰	17·9	1·4	12·8	Agostino Ameri, via Ringo, 103, Messina	Floating
585	Nello Stretto di Messina, all'imboccatura del Faro, in mezzo al Canale	38°15′ N. 15°40′ E.	9. Aug. 1912 14²⁰	18	1·3	13·8	Giuseppe e Pasquale Ingegneri, Torre di Faro, Messina	Floating
586	Do.	Do.	Do.	18	1·3	13·8	Do.	Floating
587	Torre di Faro, Stretto di Messina	38°16′ N. 15°38′,5 E.	9. Aug. 1912 18⁰⁰	18	1·5	12·0	Bancia Mario, S. Capo Elettricista, R. Staz. Fotoelettrica, Messina	
589	Al traverso del Villaggio Pace, Messina	38°14′ N. 15°35′ E.	10. Aug. 1912 5⁰⁰ p. m.	21	2·5	8·4	Paolo Defrancesco, Rotonda S. Francesco di Paola, Messina	

Experiment No. 8
(continued).

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
591	Costa di S. Francesco di Paola (Messina)	38°12′ N. 15°34′ E.	10. Aug. 1912 6⁰⁰ a. m.	23	2	11·5	Antonio Urzi, Torrente Giostra, Gassometro, Baracca 25, Messina	
592	Nello Stretto di Messina, nella spiaggia del villaggio Ganzirri	38°15′ N. 15°16′ E.	9. Aug. 1912 11⁰⁰ p. m.	20	1·7	11·8	Giovanni La Torre, di Salvatore, Ganzirri (Messina)	
593	Villaggio Pace, Messina	38°14′ N. 15°35′ E.	9. Aug. 1912 11⁰⁰ a. m.	21	1·2	17·5	Santo Costa, pescatore Villaggio Pace Messina	Wind: maestrale
594	A 1 miglio dalla costa, di fronte al villaggio Grotta (Messina)	38°14′ N. 15°35′.5 E.	10. Aug. 1912 5⁰⁰ a. m.	21	2	10·5	Agostino La Camera, via Vitt. Em., 146, Ringo, Messina	Floating
596	A circa 150 m dalla costa, all'altezza del villaggio Pace (Messina)	38°14′ N. 15°35′ E.	10. Aug. 1912	21	2	10·5	Pizzolo Francesco, fra Giuseppe Villaggio Pace, Messina	Floating
597	Nel centro del porto di Messina	38°11′.5 N. 15°34′ E.	10. Aug. 1912 6⁰⁰ a. m.	24	2	12	Lomondo, R. Torpediniera italiana 18 O. S.	Floating
598	Nello Stretto di Messina, all'altezza della punta della Grotta, a 100 metri dalla costa di Sicilia	38°14′ N. 15°35′ E.	10. Aug. 1912 6⁰⁰ a. m.	21	2	10·5	Giuseppe Polistena, Scilla (Calabria)	Floating
599	*A 200 m della spiaggia di Guardia, alla Pace* (Messina)	38°15′ N. 15°35′ E.	9. Aug. 1912 *6⁰⁰ a. m.*	21	1	21	Giov. Batt. La Fauci, fu Paolo, Villaggio Pace (Messina)	

Experiment No. 9

Liberation: Position 37°30′ N., 3°36′ E. Date 9. December 1912, 3⁴⁰ a. m. Wind SE 3. Sea SE 2.

Bottles No. 651—675,
with sand ballast, thrown out by s/s "Göben", capt. Ad. Ahlbom.

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
655	Nella spiaggia di Trapani, Sicilia	37°59′ N. 12°30′ E.	25. Febr. 1913	425	79	5·3	Marino Baldassare, Corso Vitt. Em. 209, Trapani	
658	Sulla spiaggia di Makabez, Tripolitania	33° 7′ N. 11°51′ E.	23. April 1914	620	501	1·2	Cavallaro Giuseppe, Brigadiere R.Guardia di Finanza, Makabez (Tripolitania)	
661	Nel golfo di Termini-Imerese (Sicilia), a 2 miglia da terra, a 1 miglio a Est dello scoglio della Formica	38° 4′ N. 13°35′ E.	26. Sept. 1913 14⁰⁰	180	291	1·6	Padrone della barca peschereccia "Gesù e Maria" Salvatore Cefalù fu Ignazio, da Porticello (Palermo)	Floating
666	La Chebba (Tunisie)	35°17′ N. 11°10′ E.	10. Aug. 1913	503	244	2·1	Mohamed ben Mohamed Fordjani, La Chebba (Tunisie)	
671	Trouvée en mer par la Balancelle "Ville de Bône", a 3 milles dans le Nord de la Voile Noire	37° 2′ N. 7°35′ E.	3. May 1913 11¹⁵ a. m.	195	146	1·3	M. Pernice, Capitaine de la Balancelle "Ville de Bône" Herbillon, Algérie	Floating
673	A media milla de la playa de Lloret Mar (prov. de Gerona), España	41°43′ N. 2°52′ E.	29. Aug. 1913 10³⁰ a. m.	1240	263	4·7	Felix Domenech, calle de las limones, Lloret de Mar, Gerona, España	

Experiment No. 10

Liberation: Position 38° 15′ N., 4° 10′ E. Date 9. December 1912, 7[30] a. m. Wind O. Sea O.

Bottles No. 676—700,
with sand ballast, thrown out from s/s "Göben", capt A. Ahlbom.

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
680	Al norte de la isla de Menorca, cirea al Cemaforo de Bájoli, Baleares	40° 2′ N. 3°44′ E.	19. Jan. 1913	110	41	2·7	Mateo Moll Garnel, calle Isabel 61, Islas Baleares, Menorca, Ciudadela	
689	A nord-ovest della Sardegna, nella Punta Scoglietti, a sud della Torre del Falcone, presso Stintino	40°55′ N. 8°11′ E.	4. April 1913 10[00] a. m.	219	116	2·1	Pilo G. B., pescatore, Stintino (Sassari) Sardegna	
690	Tres millas a la mar en frente de Sagunto (Valencia), España	39°38′ N. 0° 4′ W.	29. July 1913 9[00] a. m.	300	232	1·3	Vincente Maria Serra, calle José Beullume, 258 Cabañal (Valencia) España	Floating
695	San Cristobal, Menorca, Baleares, España	39°54′ N. 4° 3′ E.	7. Oct. 1913	99	302	0·3	Ignacio Martin, Coronel Carabinero	
697	Spiaggia Grande, comune di Calasetta, Sardegna	39° 6′ N. 8°23′ E.	10. March 1913	205	91	2·2	Giuseppe Zanda, avvocato, membro della Commissione compartimentale di pesca, Cagliari	
699	Près de Kerkenah (Kraïb) dans l'île Ferrekik, Sfax, Tunisie	34°45′ N. 10°50′ E.	20. June 1913	488	193	2·5	Mahmoud ben Salem Kheharem, à El-Kraïb, Kerkenah, Sfax, Tunisie	

Experiment No. 11

Liberation: Position 38° 50′ N., 4° 36′ E. Date 9. December 1912, 10[10] a. m. Wind O. Sea O.

Bottles No. 701—725,
thrown out from s/s "Göben".

Recovery

No of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
706	Dans la baie de La Chebba, près de Ras Kapoudia, Tunisie	35°17′ N. 11°10′ E.	19. June 1913	480	192	2·5	Mabrouk ben Hadj Ahmed, à La Chebba, Tunisie	
710	En la Punta de Escaleta, Bahia de Benidorme, Prov. de Alicante, España (38°31′ N. 6°12′ E. Cadiz)	38°31′ N. 0°11′ W.	10. June 1913 10[00] a. m.	225	183	1·2	D. Manuel Melia Bayona, Cabo del Cuerpo de Carabineros, Comandancia de Alicante, 3a Compañia, Alicante, España	
712	A 12 km du Cap Rosa et à 2·6 km de La Calle, Dept. de Constantine, Algérie	36°58′ N. 8°20′ E.	3. March 1913	212	84	2·5	Fauil Houcine ben Khemis, du douar Brabtia, Ce mixte de La Calle, Dept. de Constantine, Algérie	
714	Sitio denominado el "Playazo" del puesto indicado en el encabezamiento que lo baña el Mediterraneo, Rodalquilar, Almería	36°48′ N. 2° 0′ W.	18. March 1913	340	99	3·4	Juan Gómez Ramos, Carabinero del Reino, de puesto de Rodalquilar, Almería	
715	Bordj Younga, près Mahares, Tunisie	34°32′ N. 10°32′ E.	2. July 1913	530	205	2·6	Mohamed Tredj, Mahares, Tunisie	
717	Marsa Zuaga (Africa settentrionale), arenata sulla costa fra Zuara e Zavia, Tripolitania, scalo di Agilat	32°52′ N. 12°23′ E.	14. April 1913	616	126	5·0	Lusso Angelo, Sottotenente 28. Batt. Bersaglieri, Agilat, Zuara, Tripolitania	
720	Escuy de Benicudrell, Menorca, Baleares, España	39°56′ N. 3°57′ E.	25. Jan. 1913	75	47	1·6	Antonio Moll Mercadol, Pueblo San Cristobal, Isla de Menorca	
722	Ritrovata presso l'Isola Grande, Marsala, Sicilia	37°54′ N. 12°28′ E.	27. May 1913	397	169	2·2	Civetta Giuseppe, via Biscottai, cortile III, 77, Trapani, Sicilia	
724	Ibiza, S Eulalia, Puerto Calallonga, Cabo Llibell, Baleares, España	38°58′ N. 1°32′ E.	12. March 1913	144	93	1·5	Antonio Guasch Muson, Café Pedro Planas, Ibiza	

Experiment No. 12

Liberation: Position 39° 30′ N., 5° 3′ E. Date 9. December 1912, 2⁰⁰ p. m. Wind O. Sea O.

Bottles No. 726—750,
thrown out from s/s "Göben"

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
728	Costa Norte de Menorca, en el sitio conocido por Arenal den Castell	40° 2′ N. 1°14′ E.	15.March1913	50	96	0·5	Gabriel Mesquida, guardia jurada de la fenca llamada las Covas. c/o Antonio Vidal, calle San Roque, 6. Mahon, Menorca, España	
732	Cala Biniencola, Costa Sur, Menorca, España	39°48′ N. 4°13′ E.	4. Febr. 1913	45	57	0·8	Pedro Vida y Sintes, Puerta del Sol, San Luis, Menorca	
738	Spiaggia Punta Salina, Calasetta (prov. di Cagliari) Sardegna	39° 6′ N. 8°22′ E.	10.March1913	163	63	2·6	Cincotti Pino, studente, Calasetta (prov. Cagliari) Sardegna. Italia	
740	Sur les côtes de Calvi, à 25 m environ de cette ville, au lieu dit Bacaghia	42°35′ N. 8°46′ E.	3. Febr. 1913	250	56	4·5	Ambrosi François Xavier, à Calvi, Corse	
741	Cannitello, prov. di Reggio-Calabria, Italia	38°16′ N. 15°42′ E.	20. May 1913	510	162	3·1	Domenico Cogliandro, della Ditta F. lli Cogliandro & Co.	
742	Trovata da me pescatore, ad otto miglia da Terracina, verso Mezzogiorno	41°10′ N. 13°16′ E.	13.March1913	580	94	6·2	Giuseppe Disauro, Terracina (prov. di Roma)	Floating
744	Spiaggia delle Palme, 11 km da Sousa, verso Monastir, Tunisia.	35°48′ N. 10°46′ E.	11. April 1913 2⁰⁰ p. m.	420	123	3·4	Garziano Pietro, rue de Nabeul, Sousse, Tunisie	Bottiglia arenata
745	Jabiet-el-Tine, rivage du Storb Chergui, au Nord de Bahiret el Biban, qui est au SE. de Djerba.	33°45′ N. 10°46′ E.	21. May 1913 7⁰⁰ a. m.	580	163	3·6	Amor ben Salem, ben El Hafi, notaire à Zarzis, Tunisie	

Experiment No. 13

Liberation: Position 35° 53′ N., 2° 42′ W. Date 24. January 1913. Wind ESE 1. Sea 1.

Bottles No. 751—776, 786—791, 793—799, 801—825, 834, 835, 837—850,
with sand ballast, thrown out from s/s "Chr. Broberg"

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
752	Dans le rivage de Monastir, Tunisie	35°49′ N. 10°51′ E.	16. June 1913	780	143	5·5	Ahmed ben Salah el Haddad, rue Sadi Carnot, Monastir, Tunisie	
758	A 3 milles marins dans le Nord de l'île Rachegoun, par environ 35°23′ N, 3°37′ Ouest	35°23′ N. 3°37′ W.	6. Febr. 1913	70	13	5·4	Sarcia Thomas, patron de la barque "Colon", à Beni-Saf, Dept. d'Oran, Algérie	Floating
761	Nella spiaggia di Alghero (Sardegna)	40°33′ N. 8° 8′ E.	9. April 1913	625	75	8·3	Deroma Giovanni, via Doria, Alghero (Sardegna)	
764	Au Guelta par Ténès, Dept. d'Alger, Algérie	36°31′ N. 1° 7′ E.	17. Febr. 1913	198	24	8·3	Jean Garcia, au Guelta par Ténès, Algérie	
770	A Kerkenah (Charki), par Sfax, Tunisie	34°43′ N. 11°18′ E.	9. June 1913	840	136	6·2	Amord ben Ali Ammard, Kerkenah Est, Tunisie	
786	1 miles E. of Djidielli, Algérie, Philippeville, on the shore	36°50′ N. 5°52′ E.	6. March 1913	118	41	10·2	Found by the sailor Niglio Louis, sent in by the Danish Vice-Consul at Philippeville	
797	Bérinshel, au bord de la mer	36°38′ N. 2°11′ E.	3. March 1913	249	38	6·5	Nedjar Amar, Mohammed el Kébir, à Bérinshel, Cap Chenoua, Ce de Tipaza, Algérie	

Experiment No. 13
(continued).

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
804	Aux dunes à environ 5 km à l'Est du port de Philippeville, lieu dit Les Dunes, Dept. de Costantine	36°54′ N. 7° 3′ E.	10.March1913 3⁰⁰ p. m.	576	46	12·5	M. Jules Bonmarchand, firme "Les Sablons" à Valée, par Philippeville, Algérie	
818	Côte Sud Tunisienne entre Maharès et La Skira	34°24′ N. 10°20′ E.	27. July 1913	880	184	4·8	Mohammed ben Mabrouk Djelidi, chez M. Salavy, à Chahal, Tunisie	
819	Maharès, Tunisie	34°32′ N. 10°32′ E.	4. June 1913	866	131	6·6	Ahmed ben Hadj Hamouda Boukar, Maharès, Tunisie	
824	A una milla de Porto-Cristo, en Manacor, Mallorca (a los 39°32′ N. lat. y 9°31′ O. del mer. de San Fernando)	39°32′ N. 3°20′ E.	22. Aug. 1913	402	210	1·9	Salvador Vadell y Barceló, padron de pesca, calle Mayor 30, Manacor, Baleares	
843	Nella spiaggia della Marza (prov. di Bona) Algeria	36°58′ N. 7°43′ E.	15.March1913	516	50	10·3	Megini Amedi Bellabisi, Arbiglion Schek du al Ladidi, La Marza, Algeria	
845	Saïadah, Tunisie	35°43′ N. 10°52′ E.	26. May 1913 10⁰⁰ a. m.	786	122	6·4	Ahmed ben Salah Yoôbar, Ksar Hellal, Saïad, Caïda de Monastir, Tunisie	

Experiment No. 14

Liberation: Position 38° 0′ N., 10° 16′ E. Date 30. January 1913, 5⁰⁵ a. m. Wind NW 2.

Bottles No. 777—785 and 792,
thrown out from s/s "Chr. Broberg"

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
778	2 miles S. of the tower of Fogliano (which is situated halfway between Torre Astura and Monte Circello)	41°21′ N. 12°58′ E.	22. April 1913 10⁰⁰ a. m.	368	82	4·5	Sosio Cenci, c/o Mr. Stanislao Grazioli, Palazzo Caetani, Roma	
779	La Skira, Tunisie	34°14′ N. 20° 4′ E.	14. April 1913	280	74	3·8	Maître du Port de La Skira, Tunisie	
785	Entre Gabès et La Skira, sur la plage de Tarf el Ma, Tunisie	34° 4′ N. 10° 2′ E.	2. June 1913	286	155	1·8	Ahmed ben Ahmed Bali, au port, île de Kerkenah (près de Sfax) Tunisie	

Experiment No. 15

Liberation: Position 39° 0′ N., 10° 8′ E. Date 30. January 1913, 11⁴⁰ a. m. Wind SSW 2.

Bottles Nr. 800, 826—833, 836,
thrown out from s/s "Chr. Broberg"

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
826	Ras el Malah, près Kélibia (il y a 4 km entre Kélibia et Ras el Malah)	36°53′ N. 11° 6′ E.	4. March 1913	134	33	4·1	El Bechir ben Rahouma, à Hammam Guezas (Kelibia) Cap Bon à Kelibia, Tunisie	
827	Capo Carbonara (Sardegna) a 2 miglia a Nord del Fanale	39° 8′ N. 9°32′ E.	8. Febr. 1913	27	9	3·0	Bernardo Dessi, piazza Nunziata 1. Cagliari	
828	A La Chebba, au Marabout Sidi Abdallah, Tunisie	35°14′ N. 11° 6′ E.	4. May 1913	234	94	2·5	Salah ben Mohamed, Kalifa Chouchen, La Chebba, Tunisie	

Experiment No. 15 (continued).

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
830	Sulla spiaggia di Piscareddus, costa ponente, Golfo di Cagliari	39° 8′ N. 9°26′ E.	8. Febr. 1913	36	9	4·0	Enrico Zuddas, negoziante, Villasimius (prov. di Cagliari)	
831	Fidighisal, près Cap Negro, Tunisie	37° 6′ N. 8°58′ E.	22. Febr. 1913	128	23	5·6	Vincenzo Leoni, Djebel l'Albiod, Tunisie	
836	Bagnara (prov. di Reggio-Calabria) Italia	38°17′ N. 15°48′ E.	2. April 1913	270	62	4·4	Ganni Giuseppe di Giuseppe Bagnara, Calabria, Italia	

Experiment No. 16

Liberation: Position 36°5′ N., 4°40′ W. Date 22. February 1913, 5[h] a.m. Wind WNW 2. Sea WNW.

Bottles 851—1050,
thrown out from s/s "Pangan".
(Bottles 851—950 without sand ballast; 951—1050 with sand ballast).

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
861	Playa del Rinconcillo del pueblo de Algeciras, prov. de Cadiz, en España	36°10′ N. 5°26′ W.	16.March1913	36	22	1·6	Don Pedro Monaco de Torres, calle Regino Martinez, n. 11, Algeciras	
883	Encontrada dia 11 a las 7 de la mañana de Marzo, proximo del puerto de Tetuan	35°38′ N. 5°14′ W.	11.March1913 7[00] a. m.	38	17	2·2	Patron Tamete Lemarti en Tetuan, Maroc	Floating
899	Punta del Bajo, costa poniente de Africa, Ceuta, España	35°52′ N. 5°18′ W.	9. March 1913 3[40] p. m.	34	15·5	2·2	José Ortega Sanchez, Megria Andaluza, en pencionado n. 2, Ceuta	
901	Torre Moya, prov. de Malaga	36°43′ N. 4°10′,5 W.	16.March1913	44	22	2·0	Francisco Ximenes Mira, calle de Olivar, Torrox, España	
906	En el Rio Martin, cerca de Tetuan	35°38′ N. 5°14′ W.	15.March1913	38	21	1·8	Isaac S. Garzon Relojeria, Tetuan, Maroc	
911	En Rio Martin, puerto de Tetuan, Marrueccos	35°38′ N. 5°14′ W.	22.March1913	38	28	1.4	Moises ben Maman, Tetuan, Marrueccos	
920	Sur la plage de la Messida, à 12 km environ de La Calle, Algérie	36°55′ N. 8°28′ E.	7. May 1913 5[00] p. m.	636	75	8·5	Vincent Tarento, route de Tunisie, à La Calle, Algérie	
939	Puerto de Malaga, en los piedros de Morio de Levante	36°42′ N. 4°24′ W.	22.March1913	42	28	1·5	Juan Gonzalez Moya, calle Capuchino, 12, Malaga	
944	En el Rio Martin, cerca de Tetuan, Maroc	35°38′ N. 5°14′ W.	15.March1913	38	21	1·8	Isaac, Garzon Relojeria, Tetuan, Maroc	
947	En la playa del Cabo Negron (Marrueccos) Kabilos del Hans	35°42′ N. 5°18′ W.	10.March1913 4[00] p. m.	37	16·5	2·2	Manuel Ortiz, café Español, Tetuan, Marrueccos	
949	Punta Mala de Carbonera de Algeciras, España	36°12′ N. 5°23′ W.	5. April 1913	33	42	0·8	Mariano Vargas Fernandez, carabinero de caballeria, en Guardiaro (prov. de Cadiz) España	
950	Plage de Turgot, commune Rio-Salado, Dep. d'Oran, Algérie	35°28′ N. 1°13′ W.	2. April 1913	178	39	4·6	Charles Starck, adjoint special à Turgot (Dep. d'Oran) Algérie	
951	A environ 20 km à NE. du port de Bône, au lieu dit La Mafrag, Algérie	36°54′ N. 8° 5′ E.	14. April 1913	620	51	12·2	Mohamed ben Said Boukhadja, dem. au Café Maure Ben Layachi, aux Chotts à Morris, Constantine, Algérie	
952	En la playa de Cantarrajon del termino de la ciudad de Almuñecar, Granada, España	36°44′ N. 3°41′ W.	27.March1913 10[00] a. m.	62	33	1·9	Antonio Bascuñano, Haro Herradura, Almuñecar, Granada, España	

Experiment No. 16
(continued.)

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
953	A 42 km à l'Ouest de Ténès, près l'île Colombie, sur les galets, Algérie	36°27′ N. 0°55′ E.	28. July 1913	276	156	1·8	Genet Joseph, garde forestière, à Ténès, Algérie	
954	A Sidi Mechrig, 12·5 km du Cap Serrat (37°10′12″ N. 6°50′24″ E. Paris)	37°10′ N. 9°11′ E.	23. May 1913	670	90	7·4	Bettaieb ben M'hamed, Sidi Mechrig, près Cap Serrat, Tunisie	
961	Cape Negron, near Tetuan, Morocco	35°42′ N. 5°18′ W.	10.March1913	37	16	2·3	Wm. Miller (for the finder, a moor), Tetuan, Morocco	
962	15 km from Cette	43°25′ N. 3°45′ E.	26. Febr. 1914	966	370	2·6	Speroni Eugenio, Barcelona. España	
971	En la isla de Cabrera y en el sitio de la costa denominado Cala Ganduf, Baleares	39° 8′ N. 2°58′ E.	22. June 1913 2⁰⁰ p. m.	430	120	3·6	Antonio Caldentey, comandancia militar de Cabrera, Baleares	
972	Garrucha (Almería) España	37°10′ N. 1°49′ W.	18. July 1913 11⁰⁰ a. m.	178	146	1·2	José Cervantes Albarracin, Garrucha (Almería) España	
973	En el rio Martin, cerca de Tetuan	35°38′ N. 5°14′ W.	15.March1913	38	21	1·8	Mabdelofor Sordo, Rio Martin, Tetuan, Marrueccos	
978 979	En Ceuta, en la playa prente el campamento de Monte Negron	35°42′ N 5°18′ W.	10.March1913	37	16	2·3	Cristobal Cebada Perinan, soldado de la compañia de Infanteria, Extremadura N. 19, Ceuta (Africa española)	Hace 2 ó 3 dias que rema viente Est, y probablemente la botella ha sido echada à la playa à causa de dicho viente.
992	En Malaga, en la playa de San Andrès, puesto "Carrol de las Vacas"	36°42′ N. 4°24′ W.	17.March1913 5⁵⁰ a. m.	42	23	1·4	Manuel Gallego Romero, carabinero de la Comandancia de Malaga	
998	Near the river Martin, Tetuan, Marocco	35°38′ N. 5°14′ W.	12.March1913	38	18	2·1	Juan Barcelin Perez, Tetuan, Marocco	
1007	Playas de Monte Negron, à dos millas de la playa, Ceuta	35°45′ N. 5°19′ W.	16.March1913	36	22	1·6	Mojamet El-Iadad, cafetero del Negrón, Ceuta	Floating
1009	En aguas entre el Peñon y Alhucemas, prente à la Kabila de Bocoya del Rif	35°14′ N. 3°48′ W.	10.March1913	70	16	4·4	Maro Butafar, de la Kabila de Bocoya c/o Felipe Ibaneos-Comercio-Peñon, Africa Española	Floating
1025	Fué hallada en la arena de la Cala Alguitran. termino de Sontany, al Sur de Mallorca	39°20′ N. 3°10′ E.	17. July 1913	445	145	3·1	Juan Escalas S. Amor Llombars, Santany, Mallorca, Baleares, España	
1026	En la playa de Torre Nueva de Levante, à 3 km del pueblo de la atunara y 5 km y medio de Gibraltar.	36°12′ N. 5°20′ W.	12.March1913	32	18	1·8	Luis Charlo Rodriguez, Linea de la Conception, prov. de Cadiz (para José Gonzalez)	
1033	Sur la plage, à 2 milles à l'Est du Cap Sidi-Ferruch, Staouéli, Algérie	36°46′ N. 2°50′ E.	27. April 1913 7⁰⁰ a. m.	380	64	5·9	Gaillard Camille, préposé des Douanes, à Sidi-Ferruch, Algérie	
1050	Rio Martin, Tetuan, Marrueccos	35°38′ N. 5°14′ W.	23.March1913	38	29	1·3	Mohamed Ben Abdel, Sidi Temaamani, Wardia, Tetuan, Marrueccos	

Experiment No. 17

Liberation: Position 5½ miles from Cape Gallo (Sicily). Date 22. February 1913, 10³⁵ a. m. Wind NNE 5. Sea NNE 5.

Bottles No. 1051—1065, without sand ballast, thrown out from s/s "Chr. Broberg"

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
1052	Trovata in Carini, contrada Maggi	38°11′ N. 13°10′ E.	23. Febr. 1913	11	1	11	Vincenzo Conigliaro, via S. Rocco, Carini, Sicilia	

Experiment No. 18

Liberation: Position 38° 18′ N., 10° 34′ E. Date 23. February 1913, 2³⁰ a. m. Wind N 6. Sea N 6.

Bottles No. 1066—1080,
without sand ballast, thrown out from s s "Chr. Broberg"

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
1066	Spiaggia di tonnara, Sidi Daoud, Cap Bon, Tunisie	37° 5′ N. 11° 1′ E.	27. March 1913 10³⁰ a. m.	80	32	2·5	Mohamed ben Hamouda, professeur et prédicateur de Sidi Daoud, Cheidat de Hassen et Salhi, à la tonnaire de Cap Bon, Tunisie	
1067	La Chebba, au marabout Sidi Abdallah, Tunisie	35°15′ N. 11° 8′ E.	4. May 1913	190	71	2·7	Salah ben Mohamed ben Kalifa Chouchen, La Chebba, Tunisie	
1071	Stretto di Messina, spiaggia di Pezzo (Villa S. Giovanni) Calabria	38°13′ N. 15°46′ E.	22. April 1913	150	50	4·2	Renzelli Angelo, s. uff. R. Finanza [illegible]	
1076	Costa settentrionale di Sicilia, precisamente S. Agata (prov. Messina)	38° 3 N. 14°37′ E.	29. June 1913	200	127	1·6	Biagio Corso di Antonino, S. Agata di Militello (prov. di Messina)	
1077	Kerhno au . . . . . de Margi	34°42′ N. 10°47′ E.	21. April 1913	226	58	3·9	Laaressa Masaoud ben El Hadj El Kakin le Kraïbe, Capitaine de barque	
1080	Pellaro, a 6 km a Nord del semoforo di Capo d'Armi	38° 0′ N. 15°39′ E.	14. May 1913	264	81	3·3	Pasquale Vitrioli, Pellaro (prov. di Reggio-Calabria)	

Experiment No. 19

Liberation: Position 38° 43 N., 0° 4 E. Date 5 July 1913, 5ʰ p. m. Wind S 3. Sea S 3

Bottles No. 1081—1115,
without sand ballast, thrown out from s s "Pangan", Capt. Chr. Schmith

Recovery

No. of bottle	Locality	Position (approximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
1081	En la playa del Cabañal, proximo al puerto de Valencia	39°34′ N. 0°21′ W.	2. Aug. 1913	67	28	2·4	D. José Olivé Boranet, teniente de carabineros, comandancia de Valencia, Cabañal, España	
1082	Trouvé à 7 km de Cette, au lieu dit Bains de Frontignan	43°25′ N. 3°45′ E.	29. Oct. 1913	325	114	2·-	Ebarra Camille, rue Villaret Joseuse, no. 38, Cette, Hérault, France	
1084	En las inmediaciones de la playa de Badalona, prov. de Barcelona, España	41°26′ N. 2°16′ E.	1. Aug. 1913 17³⁰	184	27	6·8	José Guillemi Milá, calle seo de Urgell, Badalona (prov. de Barcelona), España	
1089	Faro de Canet de Berenguer, España	39°38′ N. 0°12′ W.	2. Aug. 1913	69	28	2·5	Rafael Bonora Tomero, Puerto de Sagunto, Valencia, España	
1090	Puerto de Fornells, Isla de Menorca (Baleares) España	40° 4′ N. 4° 9′ E.	12. Dec. 1913	200	160	1·4	Antonio Riera (pescador) calle del Mar, 10, Menorca	
1091	En Albuixech (prov. de Valencia) España	39°31′ N. 0° 6′ W.	4. Aug. 1913	44	20	2·1	D. Manuel Sanchez, Puesta de carabineros de Albuixech, Valencia, España	
1093	Entre Benicarló y Peñiscola, punto denominado el Barranquet a la orilla playa, prov. Castellón, España	40°24′ N. 0°26′ E.	14. Aug. 1913 9³⁰ a. m.	100	45	2·2	Antonio Herrera Lluch (marinero) calle S. Anselmo, n 4, Benicarló (prov. Castellón) España	
1094	Playa de Pinedo (Valencia) España	39°27′ N. 0° 2′ W.	17. Aug. 1913	70	42	1·5	Victorino Verdu Piná, comandancia de Carabineros de Valencia, 2ª compañía	
1098	A 7 millas al Sur del Cabo Tortosa (prov. Tarragona) España	40°36′ N. 0°52′ E.	2. Sept. 1913	112	56	1·4	Emilio Nicolau, S. Carlos de la Rapita (prov. Tarragona) España	Floating

Experiment No. 19
(continued).

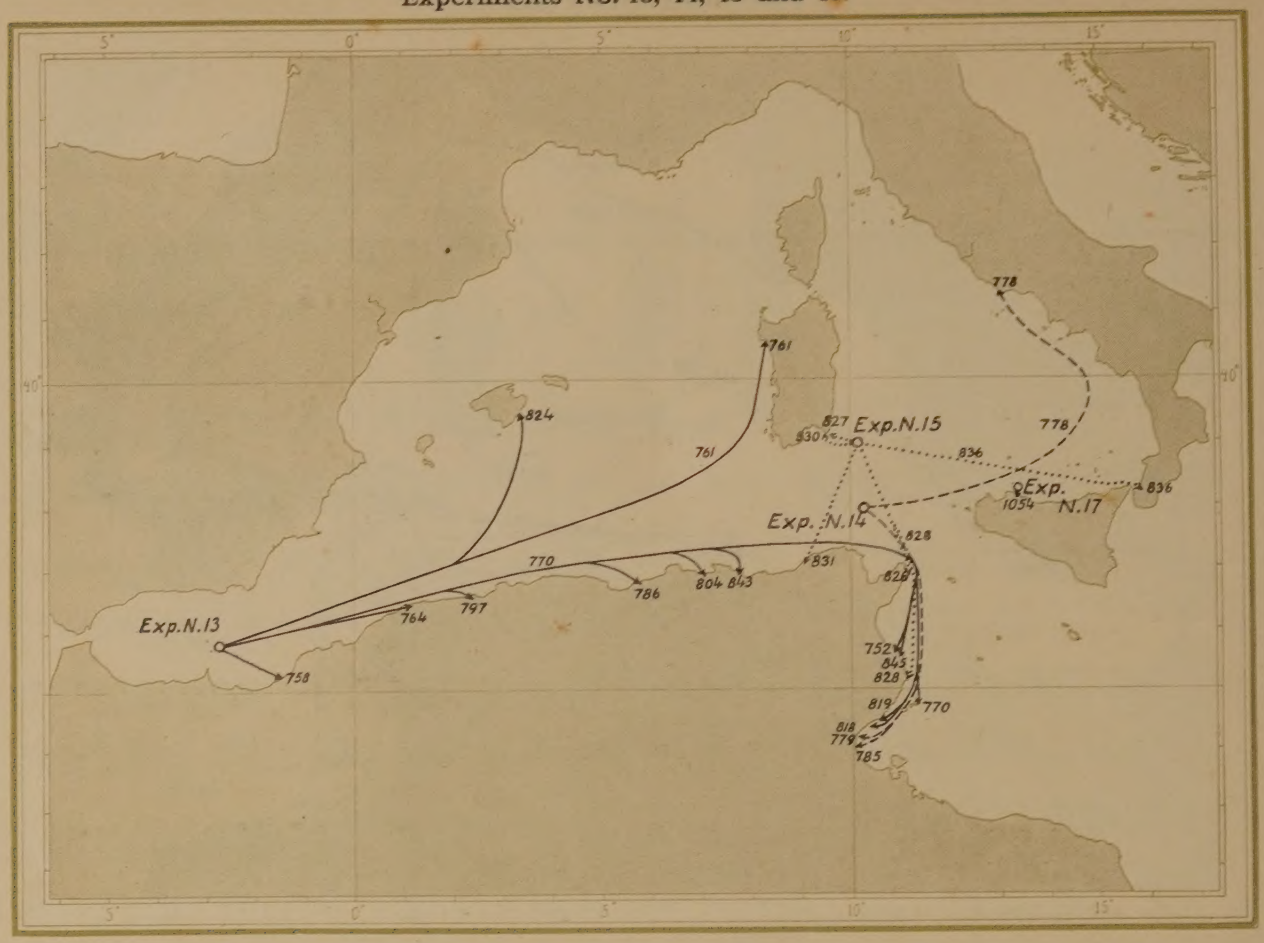
Recovery

No. of bottle	Locality	Position (aproximate)	Date	Shortest distance of drift in miles	No. of days	Average rate of drift per diem in miles	Finder	Remarks
1099	En la playa del Machistre à 5 km al Norte del puerto de Valencia, España	39°29′ N. 0°18′ W.	6. Sept. 1913	65	63	1·0	Luis Albert, calle de Serranos, 19, Valencia, España	
1100	Playa del Faro de la "Punta de la Baña" San Carlos de la Rápita (Tarragona) España	40°34′ N. 0°40′ E.	9. Aug. 1913 8⁰⁰ a. m.	112	35	3·2	Francisco Segorb, torrero de Faros, S. Carlos de la Rápita (Tarragona) España	
1103	On the beach at Albuixech (prov. of Valencia) Spain	39°31′ N. 0° 8′ W.	4. Aug. 1913	64	30	2·1	D. José Montaro, calle Mayor Nazaret, Valencia, España	
1104	En el grao de Castellon de la Plana, España	39°58′ N. 0° 3′ E.	15. Aug. 1913	82	41	2·0	Pascual Mondina Castelló, Villareal (prov. Castellón) España	
1105	Trouvée entre Soliman et Korbeus, dans le Golfe de Tunis	36°48′ N. 10°32′ E.	14. Nov. 1914	500	497	1·0	Christos D. Risos, comptable de la Société de Salias de Soliman, Tunisie	
1106	Golfo de Valencia, S. Antonio, termino de Foyo, dista 4 km de Valencia, España	39°29′ N. 0°18′ W.	2. Aug. 1913	65	28	2·3	Manuel La Trinidad, ... de Albuixech (prov. de Valencia) España	
1109	En la playa de Almazora, à 3 km del puerto de Castellón de la Plana, España	39°55′ N. 0° 5′ W.	16. Aug. 1913	82	42	2·0	José Astero Bosquet, S. Jayme n 27, Almazora (prov. Castellón de la Plana) España	
1111	En la playa de Vinaroz (prov. Castellon de la Plana) España	40°28′ N. 0°29′ E.	11. Aug. 1913	104	37	2·8	Francisco Estellez Fons, calle S. Pascual, n 4, Vinaroz, España	
1113	Golfe de Beauduc	43°24′ N. 4°36′ E.	14. Nov. 1913	330	132	2·5	Eugene Sellier, pêcheur, Stes Maries-de la-Mer, Bouches du Rhône, France	
1114	Nello stretto di Messina, fra Torre Faro (Sicilia) e Torre Cavallo (Calabria) distante dalla costa calabra circa 2 km	38°16′ N. 15°42′ E.	12.March1914 11⁰⁰ a. m.	720	250	3·0	Rocco Chemi fra Giuseppe, da Scilla (prov. di Reggio-Calabria) Italia	Floating

Experiments No. 9 and 12.

Experiments No. 10 and 11.

Experiments No. 13, 14, 15 and 17.



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